Maui County Water Use and Development Plan

Upcountry District

Final Candidate Strategies Report

Upcountry Water Advisory Committee
Review Draft

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Carl Freedman
Haiku Design & Analysis
4234 Hana Hwy.
Haiku, Maui, HI. 96708

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Introduction

This draft of the Upcountry District Final Candidate Strategies Report is intended to serve as a broadly distributed document for review of the major strategies being considered for the Upcountry District in the Maui County Water Use and Development Plan (WUDP). In order for this report to serve effectively as a "stand-alone" review document, a "Background and Context" section is included to summarize information provided in several previous chapters.

An "Executive Summary" section is provided as an overview of the Final Candidate Strategies Report. Several following sections explain the selection and formulation of the final candidate strategies and the methods used to analyze the strategies. Each of the final candidate strategies is then presented and discussed in more detail. An "Evaluation" section provides discussion and comparisons of the final candidate strategies. A "Recommendations" section provides several recommendations by the consultant / author of this report.

An Appendix presents the updated descriptions and detailed characteristics of the various resource options assumed in the analyses presented in this report.

The most recent versions of the previous supporting chapters listed below are available for download from the Maui County Department of Water Supply (DWS) web site.[1] All documents remain in the form of "drafts" pending agency approval of the WUDP.

Water Use and Demand - Department of Water Supply Systems (Draft), May 1, 2007

DWS Finance and System Economics (Draft), August 23, 2005

Resource Options (Draft), May 15, 2007

Candidate Strategies - Upcountry District Preliminary Draft, February 2007

1. Documents are available for download at the County of Maui web site at the following page: Department of Water Supply | Departments | Department of Water Supply | Resources and Planning Division | Water Use and Development Plan | Draft Water Use and Development Plan Chapters. As of the date of publication of this draft report the URL for this download page is: http://himauicounty.civicplus.com/index.asp?NID=767

Executive Summary

THE MAUI COUNTY WATER USE AND DEVELOPMENT PLAN

The Maui County Water Use and Development Plan (WUDP) is being prepared in six sections according to geographic district. The Upcountry District Final Candidate Strategies Report is expected to be the final document draft addressing the Upcountry Department of Water Supply District until a complete Water Use and Development Plan is compiled including all six districts. This Report Review Draft is being circulated for comment to the Upcountry District Water Advisory Committee, Maui County Board of Water Supply, Maui County Council and the Hawaii Commission on Water Resource Management (CWRM).

The WUDP is prepared in accordance with the CWRM "Statewide Framework for Updating the Hawaii Water Plan". An "integrated resource planning" approach is used which includes identifying planning objectives, determining future water needs, identifying all feasible means to meet future water needs and determining the best strategy to meet the planning objectives and future needs.

THE UPCOUNTRY DISTRICT WUDP PROCESS

The WUDP process for the Upcountry district began with identification of planning objectives. These objectives include a broad range of considerations including water service availability, reliability, quality, cost and broader considerations including protection of streams, water resources, cultural resources, sustainability, equity, viability, and conformance with general and community plans. Strategies to meet future water needs were evaluated with respect to each of the planning objectives. Several programs and "resources" were incorporated into the strategies to address particular objectives as necessary.

Future water needs for the Upcountry District were projected based on the planning assumptions currently being used in the preparation of the Maui general, island and community plan update. A range of high, base, and low water projections was developed to address uncertainty in future water demand. Water consumption for the DWS Upcountry District system is expected to grow from 7.2 million gallons per day (MGD) in 2005 to 8.8 MGD in 2030 (base case). Water production requirements are higher than consumption requirements by about ten percent to account for unmetered uses (such as fire protection and line flushing) and system losses.

A wide range of possible "resource options" was identified and considered. These included various options to provide new sources of water, options to conserve and use water more efficiently and options to protect stream and groundwater resources.

The most promising resource options were examined in detail using an integrated capacity expansion and production cost simulation model. This analysis tool evaluates various combinations of resources (candidate strategies) in the context of operation of the overall Upcountry District water system.

The most promising candidate strategies (final candidate strategies) were investigated, characterized and analyzed in greater detail. This is the subject of this report.

The final candidate strategies presented in this report are:

A. Incremental Basal Well Development

B. Expansion of Raw Water Storage Capacity

C. “Drought-Proof” Full Basal Well Backup

D. Improved Kamole Water Treatment Plant Capacity

E. Limited Growth With Extensive Conservation Measures

As explained in this report, each of these strategies was examined in detail to determine possible policy issues, implementation variations, costs and impacts. The strategies were compared to one another regarding each of the planning objectives. Uncertainties regarding the pace of growth in water demand, future energy costs and the viability of the strategies were analyzed and considered. Based on all of the analyses and considerations, a Recommended Upcountry District Plan was developed.

SUMMARY OF RECOMMENDED UPCOUNTRY DISTRICT PLAN

The Upcountry District is at a threshold in terms of the economics of water supply to meet new water demands. The Upper Kula and Lower Kula surface water systems are the major source of inexpensive water for this region. The reliable capacity of these sources is finite and, in the drier summer months and during drought conditions, is already at practical limits. Additional reservoir capacity can provide only limited additional reliable drought period capacity. New growth in water demand on the Upcountry system will have to be met by substantially more expensive resources.[2]

The limits on economical water sources for the Upcountry District result in several important water allocation policy issues that must be resolved. Surface water must be allocated between municipal uses, agricultural uses and the need for restoration of water to East Maui streams. In the near future the operation protocols and water pricing policies for the Upper Kula non-potable water line will have to be resolved. It is also clear that the availability of water currently diverted from East Maui streams for municipal and agricultural purposes will be reduced as amendments are made to the incumbent Interim Instream Flow Standards for these streams. The magnitude of these reductions has not been determined but it is clear that mitigating actions will be necessary in order to maintain the existing level of drought period reliable capacity provided by the East Maui Irrigation ditch system.

Meanwhile, there is a pressing need for additional water production capacity. There is an existing backlog of water demand on the Upcountry District system with a substantial waiting list for new water meters. There is frustration regarding recurrent needs to conserve water during dry periods when water is most needed for irrigation purposes.

A recommended Upcountry District Plan is provided in the final section of this report and outlined below. The Plan is intended to serve as a starting point for review and discussion for the Upcountry District section of the Maui County Water Use and Development Plan:

SUMMARY OF RECOMMENDATIONS:

SHORT TERM RESOURCES

Acquire new wells installed by Non-DWS developer as appropriate

Provide booster pump station equipment redundancy

Continue and accelerate leak detection and repair programs

Refine system operating protocols to increase productive use of existing reservoirs

Explore demand response options

LONG TERM RESOURCES

Determine the optimal specific location and feasible capacity and proceed with development of a new raw water storage reservoir for the Lower Kula surface water system

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2. Depending on location of water use, marginal production costs for new water demand in drier summer months is up to ten times as expensive as existing average water production costs. The capital costs to provide new water sources for new water services is several times higher than existing the existing system development fees intended to cover these costs.

Determine whether anticipated reductions in Wailoa Ditch base flows will be mitigated by additional basal well capacity or by providing a raw water storage reservoir to serve the Kamole Water Treatment Plant (WTP) and proceed accordingly.

Install additional booster pump capacity as necessary

Implement programmatic conservation measures

Install a new storage tank and water supply line from the Kamole WTP for the Haliimaile service area

Maintain the Opana/Awalau source as a non-potable water source and reserve for possible future source for treatment for potable use

REGULATORY MECHANISMS

Maintain and/or extend inverted block and progressive rate designs

Review system expansion financing policies and/or establish sufficient system development fees

Establish water source development contract standards

Establish clear, meaningful criteria for determining availability of water and need for new system supply resources

RESOURCE PROTECTION AND RESTORATION

Watershed Protection and Restoration

Support watershed partnership agreements

Support fencing and ungulate control programs to promote reforestation

Support programs to control invasive species

Wellhead Protection

Implement a wellhead / aquifer protection ordinance for each island

Stream Restoration

Support appropriate amendment of interim and/or permanent instream flow standards by CWRM

Support programs to protect and restore streams

Consider impacts on reliance on water from streams in County land use determinations

Protection of Cultural Resources

Support stream restoration measures

Consult with Burial Council and local kuleana representatives regarding DWS actions

ENERGY EFFICIENCY AND ENERGY PRODUCTION

Establish a DWS Energy Resource Coordinator position

Identify and implement energy efficiency opportunities

Identify and implement load management opportunities

Identify and implement energy generation opportunities

WATER ALLOCATION POLICIES

This section of the Recommended Upcountry District Plan includes a discussion of the following possible approaches to establish water allocation policies:

Venues and Purposes for Allocations

Hierarchy of Priorities

Set-Asides

Allocations of Specific Water Sources to Land Use

Statements of Allocation Policies

This draft of the Upcountry District Final Candidate Strategies Report and the Recommended Upcountry District Plan is intended to serve as a review document to promote further discussion of the issues, analyses, policies and recommendations.

Background and Context

The Hawaii State Water Plan and the Water Use and Development Plan

The Hawaii State Water Plan is required and specified as part of the State Water Code, Chapter 174C of the Hawaii Revised Statutes. The Water Use and Development Plan (WUDP) adopted by each county comprises one of the five principal components of the Hawaii State Water Plan:

- Water Resource Protection Plan - prepared by the State Commission on Water Resource Management (CWRM)
- Water Quality Plan - prepared by the State Department of Health (DOH)
- State Projects Plan - prepared by the Department of Land and Natural Resources (DLNR)
- Agricultural Water Use and Development Plan - prepared by the State Department of Agriculture (DOA)
- County Water Use and Development Plans - prepared by each County

In accordance with the State Water Code each county is required to prepare, periodically update and adopt its WUDP by ordinance. The CWRM must then adopt the WUDP as part of the Hawaii State Water Plan.

1990 Water Use and Development Plan and 1992 Draft Update

In 1990 each County in the State of Hawaii prepared and adopted its first WUDP. These WUDP's were adopted by the CWRM and were incorporated into the Hawaii State Water Plan. Each County prepared a 1992 draft update to the 1990 WUDP's. The 1992 draft WUPD updates were completed and submitted for approval but the CWRM applied more rigorous standards in its review and none of the county updates were approved. The 1990 Maui County WUDP is the most recent WUDP adopted by the county and approved by the CWRM.

CWRM Framework

The CWRM adopted a "Statewide Framework for Updating the Hawaii Water Plan" (CWRM Framework) in February, 2000. This document serves as a guideline to the state and county agencies to prepare each of the components of the Hawaii Water Plan. The CWRM Framework provides detailed specifications for preparation of the county WUDP's including an Integrated Resource Planning (IRP) analytical process and a public participation process. The IRP process outlined in the CWRM Framework and utilized by the DWS in the current WUDP update is described in more detail below.

The Current Maui County Update of the WUDP

In accordance with the Framework, the Maui County DWS presented a "Project Description" to the Maui County Council and the CWRM outlining the process that would be used by the Department of Water Supply to prepare its update of the WUDP. The Maui County WUDP is being prepared in accordance with the guidelines specified in the CWRM Framework.

The development of the Maui Upcountry District section of the WUDP has progressed through most of the phases of the IRP process including identification of planning objectives, determination of water use demand projections, identification of supply and demand-side (conservation) resource options and formulation and analysis of various sequences of options and "strategies".

All stages of the IRP process have been conducted openly with substantial public review by Water Advisory Committees. There have been twelve public meetings of the Upcountry District Water Advisory Committee (WAC). Participation in the public meetings is open and unrestricted.

Several previous documents explain the analysis and progressive derivation of the components of the strategies included in the Final Candidate Strategies Report. The most recent versions of the documents below are available for download from the Department of Water Supply web site. All documents remain in the form of “drafts” pending agency approval of the WUDP.

Water Use and Demand - Department of Water Supply Systems (Draft), May 1, 2007

DWS Finance and System Economics (Draft), August 23, 2005

Resource Options (Draft), May 15, 2007

Candidate Strategies - Upcountry District Preliminary Draft, February 16, 2007

Final Candidate Strategies Analysis Update - Upcountry District (Powerpoint slides), February 13, 2008

Final Candidate Strategies Report

The Upcountry District Final Candidate Strategies Report builds upon the previous analyses described in the documents listed above. A brief description of the previous analyses is provided in the following section of this report. Based on the previous analyses, updated information, and comments from the Water Advisory Committees, several “final candidate strategies” were characterized. The final candidate strategies include most of the previously considered strategies except that they are “reframed” and grouped to facilitate more rigorous analysis. The final candidate strategies are identified and discussed in detail in a following section of this report.

The Final Candidate Strategies Report includes a Recommended Upcountry District Plan to serve as the starting point for review and discussion. This is the first presentation of specific recommendations regarding the final candidate strategies for the Upcountry District.

Updated assumptions regarding the characteristics of the resource options incorporated in the final candidate strategies are provided in an Appendix B.

What’s Next?

The Final Candidate Strategies Report is intended to serve as a review document for consideration by the DWS, the Upcountry District WUDP Water Advisory Committee, the Board of Water Supply, the CWRM, the Maui County Council and the general public. Based on comments and discussion of this Report, a Draft Upcountry District Plan can be compiled (along with the drafts addressing other Maui districts and non-DWS users and purveyors) for review and approval as the updated Maui County WUDP.

Description of the Analytical Process

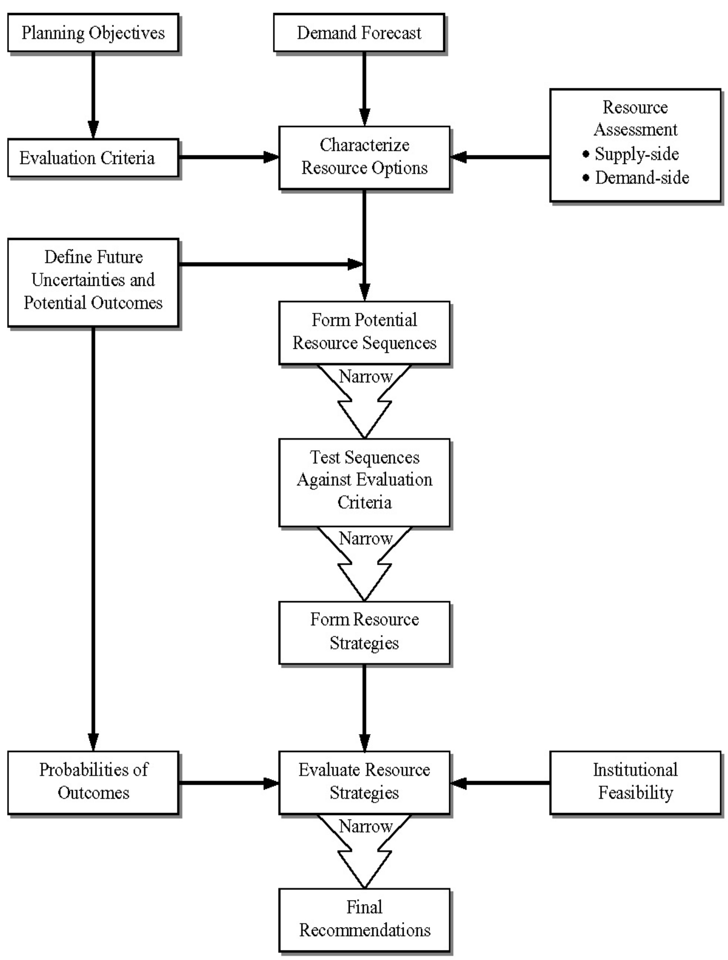
The Integrated Resource Planning Process

The CWRM Framework provides detailed specifications for the procedures to update the county WUDP's including an Integrated Resource Planning (IRP) process. The IRP process is adapted from similar planning procedures used widely in the electric power industry. IRP provides for "integration" of several types of planning components:

- Integration of conventional water supply resources with "demand-side" conservation resources (implemented on the customer "side" of the water meter)
- Integration of public participation in the planning process
- Integration of non-monetary, societal, cultural, environmental and economic consider-ation in long range utility planning

The IRP process is depicted below on a chart from the CWRM Framework. The process begins with identification of the planning objectives that are to be fulfilled by the WUDP and used to evaluate the merits of alternate planning strategies. Long range projections of water needs are prepared to serve as the basis for water resource planning. A wide and inclusive spectrum of supply-side and demand-side resource options is identified and characterized. These resource options are evaluated and the more promising options are assembled into resource "strategies." Each strategy is a sequence of resource options designed to meet the water needs and planning

Figure 2-2
ELEMENTS OF AN IRP PROCESS



objectives over a long term (twenty-five year) planning time frame. The alternative “candidate” strategies are evaluated and compared to one another to determine a set of “final candidate strategies” for rigorous analysis and consideration for the WUDP. The IRP process implemented for the Upcountry District is described below in greater detail.

Identification of Planning Objectives

A set of planning objectives was determined for the Upcountry District based on input from the Upcountry District Water Advisory Committee (Upcountry WAC). At the first meeting of the Upcountry WAC suggestions for planning objectives were solicited. A resulting extensive list of objectives, comments, policies and suggested resources was recorded. These were sorted and grouped to determine a more concise list of planning objectives. At subsequent Upcountry WAC meetings the list of planning objectives was reviewed, extended and amended. The resulting list of planning objectives for the Upcountry District is provided below:

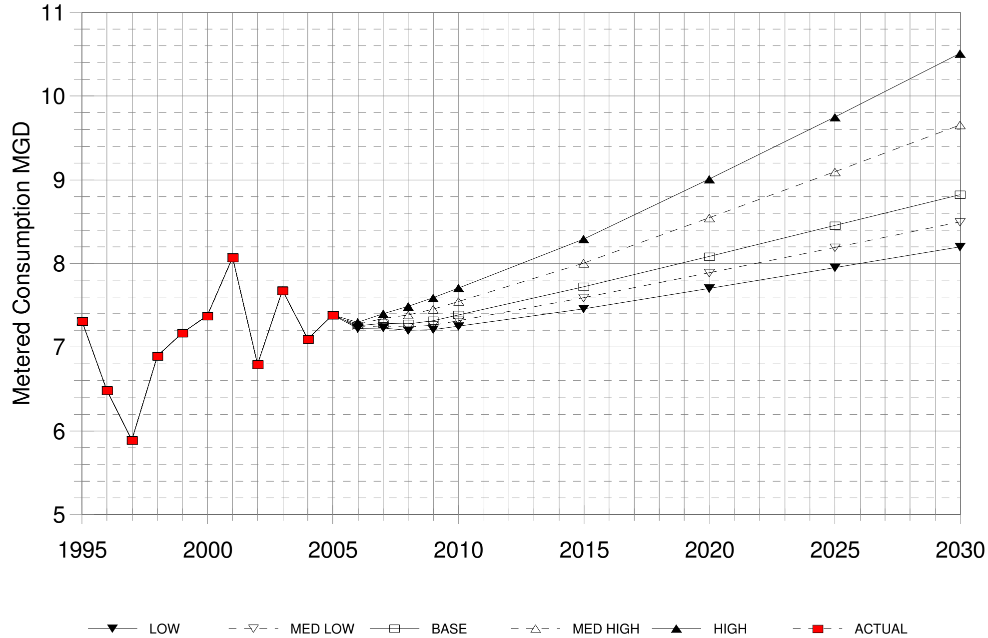
PLANNING OBJECTIVES

Availability	Provide Adequate Volume of Water Supply
DHHL	Provide For Department of Hawaiian Homelands Needs
Agriculture	Provide For Agricultural Needs
Cost	Minimize Cost of Water Supply
Efficiency	Maximize Efficiency of Water Use
Environment	Minimize Adverse Environmental Impacts
Resources	Protect Water Resources
Streams	Protect and Restore Streams
Culture	Protect Cultural Resources
Quality	Maximize Water Quality
Reliability	Maximize Reliability of Water Service
Equity	Manage Water Equitably
Sustainability	Maintain Sustainable Resources
Conformity	Maintain Consistency with General and Community Plans
Viability	Establish Viable Plans

Characterization of Long Range Water Demand

Projections of water demand for the twenty-five year planning period were derived for the DWS Upcountry District. The projections and the analyses, assumptions and procedures used to derive the projections are presented in detail in the *Water Use and Demand* chapter. Water demand for the Upcountry District for the planning period is depicted below for a range of assumptions that result in a base case and high, low and medium high and medium low water demand growth scenarios.

DWS Actual and Projected Consumption
Total All Classes   Upcountry District



Actual and Projected Water Demand (Metered Consumption), DWS Upcountry District, All Metered Uses.

ECONOMETRIC COMPOSITE WATER CONSUMPTION PROJECTIONS (Millions of Gallons per Day

DWS Projections Indexed to Maui County General Plan Update: Socio-Economic Forecast Report 2006

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030
Upcountry														
	Low Case	4.399	4.401	4.372	4.383	4.423	4.465	4.506	4.547	4.588	4.630	4.874	5.122	5.373
	Medium Low Case	4.404	4.410	4.386	4.401	4.446	4.492	4.537	4.582	4.628	4.673	4.928	5.185	5.444
General	Base Case	4.408	4.419	4.400	4.419	4.469	4.519	4.568	4.618	4.667	4.717	4.982	5.249	5.516
	Medium High Case	4.426	4.469	4.491	4.539	4.607	4.676	4.745	4.814	4.883	4.952	5.367	5.787	6.212
	High Case	4.445	4.520	4.583	4.660	4.747	4.836	4.924	5.013	5.102	5.191	5.756	6.331	6.915
	Low Case	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258	2.258
	Medium Low Case	2.265	2.272	2.278	2.285	2.292	2.299	2.305	2.312	2.319	2.326	2.361	2.397	2.434
Ag Potable	Base Case	2.272	2.285	2.298	2.312	2.326	2.340	2.354	2.368	2.382	2.397	2.472	2.551	2.634
	Medium High Case	2.275	2.292	2.309	2.326	2.343	2.361	2.379	2.397	2.415	2.433	2.530	2.633	2.744
	High Case	2.278	2.298	2.319	2.339	2.361	2.382	2.404	2.426	2.448	2.471	2.591	2.721	2.862
	Low Case	6.657	6.659	6.631	6.641	6.682	6.723	6.764	6.805	6.847	6.888	7.132	7.380	7.631
	Medium Low Case	6.668	6.682	6.664	6.686	6.738	6.790	6.842	6.895	6.947	6.999	7.289	7.583	7.879
Total Potable	Base Case	6.680	6.704	6.698	6.731	6.795	6.858	6.922	6.986	7.050	7.114	7.454	7.800	8.150
	Medium High Case	6.701	6.761	6.799	6.865	6.950	7.037	7.124	7.211	7.298	7.386	7.897	8.420	8.956
	High Case	6.723	6.818	6.902	6.999	7.107	7.218	7.328	7.439	7.550	7.662	8.347	9.051	9.778
	Low Case	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573
	Medium Low Case	0.575	0.577	0.579	0.581	0.583	0.585	0.586	0.588	0.590	0.592	0.602	0.612	0.622
Ag Non Potable	Base Case	0.577	0.581	0.584	0.588	0.592	0.596	0.600	0.604	0.608	0.612	0.633	0.654	0.676
	Medium High Case	0.578	0.583	0.587	0.592	0.597	0.602	0.607	0.612	0.617	0.622	0.649	0.676	0.704
	High Case	0.579	0.584	0.590	0.596	0.602	0.608	0.614	0.620	0.626	0.633	0.665	0.699	0.734
	Low Case	7.230	7.232	7.204	7.214	7.255	7.296	7.337	7.378	7.420	7.461	7.705	7.953	8.204
	Medium Low Case	7.243	7.258	7.243	7.267	7.320	7.375	7.429	7.483	7.537	7.592	7.891	8.195	8.501
Total	Base Case	7.257	7.285	7.283	7.320	7.387	7.455	7.522	7.590	7.658	7.726	8.086	8.454	8.826
	Medium High Case	7.279	7.343	7.387	7.457	7.547	7.639	7.731	7.823	7.915	8.008	8.546	9.096	9.660
	High Case	7.302	7.402	7.492	7.595	7.710	7.826	7.942	8.059	8.177	8.294	9.012	9.750	10.512

Actual and Projected Water Demand (Metered Consumption), DWS Upcountry District, All Metered Uses.

DWS Upcountry System Total										
DWS Water Demand, Production and Source Use										
								Criteria Water Requirements		
	Water Demand					Water Demand		Drought Demand	Criteria Demand	Criteria Demand
	Med.High v31	Med.High v31						Average	Peak Day	Peak Day
	Metered		Unmetered			Production		Factor	Factor	w/Unmetered
	Consumption		System			Net to System		1.080	1.500	
Year	kgals	MGD	kgals	MGD	% of Prod.	kgals	MGD	Avg. MGD	Peak MGD	Peak MGD
1994	2,055,226	5.631								
1995	2,371,190	6.496								
1996	2,135,086	5.850								
1997	1,970,274	5.398								
1998	2,276,075	6.236								
1999	2,359,116	6.463								
2000	2,447,079	6.704								
2001	2,632,724	7.213								
2002	2,273,438	6.229								
2003	2,533,840	6.942	281,538	0.771	10.0%	2,815,378	7.713	7.497	11.246	12.017
2004	2,325,314	6.371	258,368	0.708	10.0%	2,583,682	7.079	6.880	10.321	11.028
2005	2,422,947	6.638	269,216	0.738	10.0%	2,692,164	7.376	7.169	10.754	11.491
2006	2,381,392	6.524	264,599	0.725	10.0%	2,645,991	7.249	7.046	10.569	11.294
2007	2,479,540	6.793	275,504	0.755	10.0%	2,755,045	7.548	7.337	11.005	11.760
2008	2,570,391	7.042	285,599	0.782	10.0%	2,855,990	7.825	7.606	11.408	12.191
2009	2,577,835	7.063	286,426	0.785	10.0%	2,864,261	7.847	7.628	11.441	12.226
2010	2,592,610	7.103	288,068	0.789	10.0%	2,880,678	7.892	7.671	11.507	12.296
2015	2,669,025	7.312	296,558	0.812	10.0%	2,965,583	8.125	7.897	11.846	12.659
2020	2,803,099	7.680	311,455	0.853	10.0%	3,114,554	8.533	8.294	12.441	13.294
2025	2,987,818	8.186	331,980	0.910	10.0%	3,319,798	9.095	8.841	13.261	14.171
2030	3,176,963	8.704	352,996	0.967	10.0%	3,529,959	9.671	9.400	14.100	15.068

Projected Water Consumption, Production and Capacity Criteria Requirements, DWS Upcountry District, All Metered Uses.

The econometric model used to make the water demand projections predicted reductions in consumption in the near term in the base case and low cases. The predicted reductions are due to recent increases in water prices (despite continued increases in new customer accounts). Consumption for the year 2008 was predicted to be slightly lower than prior years. Actual consumption for the year 2008 has been substantially lower than predicted, due, in part, to higher water prices and lower defacto population resulting from the recent economic downturn starting in mid-2008. The system and economic analysis described in this report presume that water demand will increase in the long term as shown in the chart above. This is consistent with the assumptions in the socio-economic studies prepared by the County supporting the current General Plan update process.

Characterization of Specific Resource Options

Resource options are broadly defined to include any actions, programs or measures that serve to fulfill the planning objectives. Resource options include, for example, programs to protect and restore watersheds, as well as conservation programs and rate design policies.

An extensive list of resource options was compiled and extended with review by the Upcountry WAC. The resource options are documented in the *Resource Options* (May, 2007) draft chapter.

Several specific supply resource options were identified for the DWS Upcountry District system. For meaningful incorporation in the analysis of candidate strategies these resource options were characterized in detail and were classified as follows:

- **Committed Resource Options** - options that are in the process of being implemented but are not yet in service

- **Short Term Resource Options** - options that could mitigate immediate capacity reserve shortfalls
- **Long Term Resource Options** - alternative options that would form the fundamental basis of the resource strategies and would address the identified planning objectives over the time frame of the planning period
- **General Resource Options** - options that are not exclusive and can be implemented in conjunction with most other combinations of options.

The Committed and Short Term resource options are included in each of the candidate strategies. The Long Term resource options are the major options that are, at least to some extent, mutually preclusive. The Long Term strategies are evaluated against one another in the analysis of the candidate strategies. The General resource options are measures that could be implemented in conjunction with any of the strategies. These are evaluated independently.

The characteristics of each of these resource options are identified in substantial detail in the *Candidate Strategies* (February, 2007) draft chapter. Updated detailed characterizations used in the analysis of the Final Candidate Strategies are provided as an appendix to this report.

Supply Resource Option Characterization — **All Costs Expressed in $2004**

Option Name	Plant Capacity			Capital Cost		Fixed Operating		Variable Operating	Plant Life
	Installed	Criterion	Effective	Cost	Unit Cost	Cost	Unit Cost	Cost	Economic
	MGD	MGD	MGD	$M	$M/MGD	$/Year	$/Year/MGD	$/kgal	Years
Well - Pookela (Committed)	1.296	0.864	1.000	$3.950	$3.950	$55,523	$55,523	$2.62	30
Well - MLP Well #1	1.296	0.864	1.000	$7.004	$7.004	$56,700	$56,700	$2.69	30
Well - MLP Well #2	1.296	0.864	1.000	$6.379	$6.379	$55,523	$55,523	$2.62	30
Well - DWS 1600' Site (Makawao)	1.296	0.864	1.000	$6.088	$6.088	$55,523	$55,523	$2.62	30
Well - DWS 1300' Site (Makawao)	1.296	0.864	1.000	$5.807	$5.807	$43,753	$43,753	$1.89	30
GAC Treatment for Groundwater Well	0.000	0.000	2.000	$2.323	$1.162	$26,298	$13,149	$0.05	30
100 MG Raw Water Reservoir for Piiholo WTP	1.190	1.190	1.190	$30.248	$25.419	$60,000	$50,420	$0.00	100
300 MG Raw Water Reservoir for Piiholo WTP	2.590	2.590	2.590	$79.414	$30.662	$60,000	$23,166	$0.00	100
500 MG Raw Water Reservoir for Piiholo WTP	3.510	3.510	3.510	$128.579	$36.632	$60,000	$17,094	$0.00	100
300 MG Raw Water Reservoir for Olinda WTP	1.050	1.050	1.050	$79.414	$75.632	$60,000	$57,143	$0.00	100
100 MG Raw Water Reservoir for Kamole WTP	4.500	4.500	4.500	$26.151	$5.811	$60,000	$13,333	$0.00	100
200 MG Raw Water Reservoir for Kamole WTP	7.290	7.290	7.290	$46.637	$6.397	$60,000	$8,230	$0.00	100
300 MG Raw Water Reservoir for Kamole WTP	8.640	8.640	8.640	$67.122	$7.769	$60,000	$6,944	$0.00	100
500 MG Raw Water Reservoir for Kamole WTP	9.450	9.450	9.450	$108.093	$11.438	$60,000	$6,349	$0.00	100
Awalau / Opana Tunnel Source Development	2.590	0.000	0.400	$11.565	$28.912	$14,000	$35,000	$0.72	50

Integrated Analysis of Candidate Strategies

The specific resource options and candidate strategies were analyzed in the "integrated" context of the operation of the DWS Upcountry District system. An integration model was developed for the Upcountry District systems that serves as a capacity expansion and production cost model.

The integration model considers the following elements for each of the inter-related Upcountry systems:

- The forecast of water demand for the twenty-five year planning period (2006 - 2030)
- Average, annual peak, daily peak and drought year variability of water demand
- The characteristics and costs of operating the existing water system resources
- Inflation, escalation, cost of capital estimates and discounting assumptions
- Limits on allowed aquifer withdrawals
- System expansion criteria derived for planning analysis purposes
- Costs and characteristics of available resource options
- Forecast of electricity costs and calculation of system production costs

The integration model analyzes and calculates the following elements:

- Calculation of system fixed operation and maintenance costs
- Calculation of system capital costs
- Determination of annual and discounted planning period costs
  - Costs by category including Variable, Fixed O&M and Capital costs
  - Costs by perspective including "utility", "total resource" and "participant" costs
- Rate impacts stated as average annual % rate increase and levelized rates.
- Determination of unserved water demand and reserve capacity shortfalls
- Tabular and graphic portrayal of input assumptions and analysis results

The four Upcountry District systems were modeled individually but interactively, taking into consideration the water demands of each system, the production resources of each system, and the ability, economics and necessity of water transfers between the systems. Water transfers between systems are modeled based on economics (when providing water from an another system is less expensive considering any pumping or transfer costs) and based on need (when water needs on a system cannot be met by resources on that system). Transfers between systems take into consideration limitations on booster capacity. Booster capacity is added in a future year if and when this becomes necessary. The variable and fixed operating costs (and the capital costs of additional needed booster capacity) of transfers between system are calculated and accounted in the system costs.

The Upcountry District systems are modeled sequentially for each year of the analysis in both average and drought conditions. This is important because of the sensitivity of the surface water systems to both average and drought period conditions. Drought period production capability is important in determining the dates that additional production resources are needed to maintain system reliability.

In the analysis of the candidate strategies several necessary assumptions were made regarding system reliability standards, resource capacity addition criteria and system operating protocols. These standards and criteria were examined and refined in the process of analyzing the Candidate Strategies.

Using the integration model the analysis of the specific resource options and candidate strategies was conducted in several stages:

- **Determination of a Reference Strategy**: A base case combination and sequence of resource options was determined to serve as a reference strategy against which other possible strategies were compared.
- **Integrated Analysis of Individual Resource Options**: Each of the principal resource options was analyzed in the integrated context of the operation of the DWS Upcountry District system.
- **Formulation and Preliminary Optimization of Candidate Strategies**: Each principal resource option was analyzed to determine what combination of other resource options would best combine to comprise a candidate strategy.
- **Evaluation and Comparison of Candidate Strategies**: The candidate strategies were analyzed and compared.

The analysis of the candidate strategies is described in detail in the *Candidate Strategies* (February, 2007) draft chapter.

Formulation and Analysis of Final Candidate Strategies

Several of the candidate strategies were formulated into "final" candidate strategies in order to facilitate more rigorous analysis and detailed specification. Several final candidate strategies were characterized based on discussion with the Upcountry WAC. The determination and analysis of final candidate strategies was presented for review and discussion to the Water Advisory Committee, the Board of Water Supply and the Water Resources Committee of the Council. The final candidate strategies and analyses are described in the next section of this report.

Independent Components Considered in All Strategies

This section of the Final Candidate Strategies Report considers several resources and possible plan components that could be included in any of the final candidate strategies. These "independent components" are presented below in two categories: (1) measures that apply primarily to the DWS water system and (2) measures that apply County-wide.

DWS System Measures

The following measures apply primarily to the DWS system. Measures that apply more broadly are listed in a following section on County-Wide Measures.

Demand-Side Management (Conservation) Programs

"Demand-side management" (DSM) is a utility industry term for actions taken by a utility to promote conservation by the utility's customers. Originally applied to the electric utilities and applied now also to gas and water utilities, DSM options have proven to be valuable "resources" to meet utility planning objectives.

DSM resource options are usually programs undertaken by a utility to encourage the use of efficient appliances or practices by its customers or to encourage customers shift their time of use. DSM programs often provide for direct installation of efficient fixtures or appliances, or use incentives such as monetary rebates to encourage purchase of efficient fixtures or appliances.

DSM programs are evaluated based on a comparison of the costs of programs to promote water savings with the costs the utility and its customers would otherwise incur to develop and operate new supply resources. For the Upcountry District system DSM conservation programs cost less than new supply resources.

- A basic Upcountry conservation program portfolio targeting retrofit of inefficient indoor fixtures spending $162,000 per year for five years (net present value $614,000) would reduce DWS planning period expenditures by $1.4 million (NPV).
  - Planning period capital requirements would be reduced by $510,000 (NPV).
  - Planning period operating costs would be reduced by $934,000 (NPV) assuming the low energy price scenario.
  - This portfolio of conservation programs was originally evaluated and included in each of the final candidate strategies. After further evaluation, the more aggressive program portfolio below was included in the final candidate strategies.
- A more aggressive conservation program portfolio targeting three times the penetration of the program above, spending $ 364,000 per year for ten years ($3,037,000 NPV), would reduce DWS planning period expenditures by 4.0 million (NPV).
  - Planning period capital requirements would be reduced by $ 1.5 million (NPV).
  - Planning period operating costs would be reduced by $ 2.5 million (NPV) assuming the low energy price scenario.
  - This portfolio of conservation programs was originally considered in the Limited Growth with Extensive Conservation Measures strategy but, because it is a preferred strategy component, is now included in all of the principal candidate strategies.

DSM programs at a spending level of approximately $364,000 per year (for the Upcountry District system) are included in all of the principal final candidate strategies. It is recommended that a DSM specialist be retained by the DWS to determine and assist the DWS to implement a portfolio of DSM programs including the elements below. These elements, in sum, would result in greater reductions in water demand and would likely be more cost-effective than the portfolio of programs modeled in the analyses and characterized above.

- residential / commercial audit and direct installation program for indoor and landscape irrigation users
- education and publicity program to encourage water conservation and promote program participation
- direct installation of efficient fixtures at customer premises including toilet, showerhead and sink faucet flow restrictors
- audit of existing irrigation system equipment and practices and specific resulting recommendations to customer to improve efficiency
- direct installation of targeted “high payback” fixtures in commercial premises
- high efficiency fixture rebates
- high efficiency washing machines
- high efficiency toilets and waterless urinals
- hotel awards program
- building manager user group and services
- agricultural user group and services

There are several issues associated with utility implementation of DSM programs that should be considered from a policy perspective:

- DSM programs, if cost-effective, will reduce total customer bills (utility revenue requirements). Rates, however, will not necessarily be reduced because effective DSM lowers the amount of water produced and sold. Lowering the volume of water sold in the long term tends to increase rates since the fixed costs of the utility must be collected from fewer units of water sold.
- Program costs are supported by all utility ratepayers generally but provide more benefits to participating customers than non-participating customers. All customers benefit to some extent because DWS costs are reduced in the long term (if the DSM programs are, in fact cost-effective) but non-participating customers may not have a net benefit if DSM implementation results in higher rates. For this reason it is important that all customers have some reasonable opportunity to participate in DSM programs.
- Mandatory codes and requirements are possible alternatives or complimentary measures to DSM programs. Mandatory codes could be established that require installation of fixtures that are more efficient than existing federal standards or that restrict some types of water use. Mandatory measures are generally less expensive for the County to implement because they do not require utility expenditures on incentives to customers or program administration costs. In order to be effective, however, some programmatic enforcement measures may be required.

Measures to Mitigate Impacts of Reductions in Wailoa Ditch Base Flows

Recent and anticipated amendments to the interim instream flow standards (IIFS) on East Maui streams will reduce the base flow of the Koolau/Wailoa Ditch system which is the water source for the Kamole water treatment plant (WTP). Unless measures are taken by the DWS to mitigate the these reductions in base flows the drought period reliability of the Upcountry District system would be diminished. Several mitigation actions are assessed in the sections below describing the final candidate strategies. Mitigation actions could include providing raw water reservoir storage for the Kamole WTP or addition of basal groundwater well capacity to provide alternate drought period reliability.

Supply Side Leak Detection and Reduction Measures

The DWS examines its system for leaks in transmission and distribution pipes using special equipment designed for this purpose. In addition to DWS leak detection procedures, contractors are available to provide services to the DWS to conduct specialized leak detection surveys using several techniques.

Supply side leak detection and reduction is consistent with all other options under consideration and can be expected to be implemented on an ongoing basis to the extent that measures are determined to be cost effective.

Recycled Water Use Options

The Upcountry District has only limited wastewater treatment facilities. Most of the district utilizes private on-site septic systems for wastewater disposal. Where wastewater is treated there is an opportunity to use properly treated effluent for irrigation purposes. Currently the Pukalani Sewage Treatment Plant produces recylcled wastewater that is used for irrigation of the Pukalani Country Club golf course. Unless additional wastewater treatment facilities are built in the Upcountry District, there are not extensive opportunities to utilize treated wastewater to displace potable water requirements.

Water Quality Improvement Measures

The DWS is currently investigating measures to reduce water treatment disinfection byproducts for the surface water treatment plants on the Upcountry District System. Investigation of several alternative disinfectants and treatment technologies is proceeding by Brown & Caldwell under contract to the DWS.

Production Energy Efficiency Measures

Energy use is a substantial component of DWS costs. Investments in energy efficient equipment can reduce long term costs of providing water service. Measures to increase the energy efficiency of water production are consistent with all of the candidate strategies. Specific measures are included in the Recommendations section of this report.

Potential Power Management Services

The DWS is the largest single consumer of electricity on the Island of Maui. Most energy consumed by the DWS is used to operate motors for pumps that lift water to storage tanks and reservoirs. The DWS water storage capacity is not generally sufficient to provide classic “pumped storage” benefits for the electrical system by “firming” intermittent renewable energy sources. The DWS system does, however, have a unique capability to provide valuable short term electric demand response services that are valuable to the electric utility.

The Maui utility electrical system needs short term “stabilizing” power management capability to accommodate growing proportions of new wind and other variable renewable energy sources. The DWS could potentially provide economical short-duration energy management services to help follow more rapidly changing generation “transients” as the output of renewable energy sources change during the course of each day. This capability has a value to the electric company which, if effectively implemented and negotiated, could benefit both Maui’s electricity and water customers.

Energy Production Options

Energy production for use by the DWS is a potentially cost effective option that would be consistent with any of the candidate strategies. Wind generation is a cost effective option for the DWS Upcountry District system.

Several wind generation sites were examined and several configurations of generation, use and transmission options were analyzed. All of the following configurations were analyzed assuming the use of relatively small 50 KW wind turbine generators (approx. 50 foot blade diameter):

- 50 to 100 KW generation net energy metered (NEM) at the Kamole WTP
- 200 to 300 KW generation NEM plus dedicated pump loads at Kamole WTP
- 500 KW generation with surplus energy spilled
- 500 KW generation NEM or Feed-in Tariff
- 1 MW wind farm at Maliko Gulch area under several scenarios
    - Energy sold to Maui Electric Company (MECO) by Power Purchase Agreement
    - Energy wheeled by MECO to Kamole WTP and DWS booster pump sites
    - Energy distributed to DWS sites with DWS built transmission lines
    - Energy distributed to DWS sites with DWS conductoring on MECO poles

All of the wind generation scenarios analyzed included costs of financing, construction, maintenance, environmental studies and administrative overhead. Most options were cost effective at the high energy cost scenario assumptions. Some were cost effective at the low energy cost scenario assumptions.

A practical and cost-effective option as a first stage of power production development would be to install a net energy metered wind generation installation at the Kamole WTP site. Partnering arrangements should be investigated to take advantage of substantial financial opportunities and tax credits that are not available to government agencies.

Wind generation is discussed in more detail in an appendix to this report.

Energy production and energy efficiency measures serve several of the WUDP planning objectives including: Cost, Efficiency, Environment, and Sustainability.

Water Rate Design and Pricing Policies

The design of water rates is an effective means to encourage efficient water use. The DWS now has an inclining block water pricing structure. Each customer pays increasing rates for increasing volumes of water. This is a means to encourage water conservation because the savings to the customer resulting from reduced consumption are based on the highest price block for the customer and are thus higher than the average cost of water.

For the Upcountry District several rate design options may be appropriate for consideration. These include rates based differentiated based on service elevation, annual season or drought periods. These options and the subject of water rate design generally are discussed in more detail in the DWS Finance and System Economics Chapter of the WUDP. Specific recommendations are provided in the Recommendations section of this report.

County - Wide Measures

Watershed Protection and Restoration

Watershed protection and restoration measures are consistent with all of the candidate strategies and are presumed to be part of all of the candidate strategies. These measures will be discussed in detail in a separate section of the WUDP.

Maintaining healthy forests is essential to maintaining the healthy streams and groundwater aquifers that are the source of our water supplies. These resources need protection and, in some places, substantial restoration. Healthy forests invite and capture precipitation, retain water to replenish aquifers, maintain base flow in streams, prevent soil erosion and flooding and maintain stream water quality.

The DWS currently supports watershed partnership agreements, control of invasive species that threaten watershed areas and reforestation programs.

These measures serve several WUDP planning objectives including: Environment, Sustainability, Quality, Streams, and Resources.

Stream Restoration Measures

Stream restoration measures are consistent with any of the candidate strategies and may be an integral component of some of the surface water treatment strategies. The county has supported the establishment of appropriate amended interim instream flow standards and endorsed the concept of "mauka to makai" flow for Maui's streams.

Stream restoration measures affect several WUDP planning objectives including: Availability, Cost, Environment, Equity, Sustainability, Streams, Resources, Agriculture and Culture.

Wellhead Protection Ordinance

A wellhead protection ordinance was presented to the WAC and will be described in detail in a separate section of the WUDP. A wellhead protection ordinance would limit activities in areas around potable wells that could potentially contaminate groundwater aquifers.

A wellhead protection ordinance would serve several WUDP planning objectives including: Environment, Sustainability, Quality, and Resources.

Well Development Policies and Regulation

Well development policies and regulation measures are possible options to ensure that wells are sited in suitable and preferred locations, and that contracts for the development of water sources are fair and provide equitable benefits to developers and DWS customers. Provisions of a well development policy could address the following matters:

- Determination of well locations to ensure water quality, proximity to DWS water lines, minimize DWS system operation costs and allow wellhead protection measures to maintain water quality
- Determination and denomination of source credits and water entitlements in source development contracts

Specific recommendations are provided in the Recommendations section of this report.

These measures would serve several WUDP planning objectives including: Cost, Efficiency, Environment, Quality, and Resources.

Landscape Irrigation Efficiency Requirements

A draft conservation ordinance has been drafted for consideration by the County of Maui that includes landscape irrigation efficiency requirements. This ordinance will be described in a separate section of the WUDP. The proposed ordinance would reduce future water needs by limiting landscape irrigation uses to reasonable alternatives.

The proposed ordinance would serve several WUDP planning objectives including: Availability, Cost, Efficiency, and Sustainability.

Drought Water Use Restrictions

Restrictions on water use during drought conditions is a demand management measure now used for the DWS Upcountry District system. If the Upcountry District system relies increasingly on surface water sources, drought water restrictions could be a means to manage water demand and reduce system costs.

Several alternative forms of drought water restrictions are possible. The restrictions now applied to the Upcountry system limit water use for each customer based on historical use volume. Another way to implement drought water restrictions would be to limit the types of uses for which water could be used during drought conditions.

Final Candidate Strategies

In previous analysis and presentations reports various strategies were considered to meet the planning objectives for the DWS Upcountry District. The "final candidate strategies" for the Upcountry District represent five fundamental alternative approaches to meet projected water needs for the twenty-five year planning period. Each strategy is distinguished by a different featured major approach to meeting new water needs:

A. Incremental Basal Well Development
B. Expansion of Raw Water Storage Capacity
C. "Drought-Proof" Full Basal Well Backup
D. Improved Kamole Water Treatment Plant Capacity
E. Limited Growth With Extensive Conservation Measures

In addition to these distinguishing features there are many components that are included in all the strategies. These include:

- **Existing Resources** - Resources that are currently part of the DWS Upcountry District system
- **Committed and Near Term Resources** - New supply resources that are already in the process of acquisition, development or construction
    - Pookela Well
    - Olinda WTP Upgrade
    - Makawao System Basal Well
    - Kamole WTP Upgrade
    - Phase 6 and Phase 10 Booster Pump Upgrades
- **Demand-Side Management (Water Conservation) Programs** - Based on previous and updated analysis a portfolio of water conservation programs is included in all strategies. The programs are designed to attain 45 percent of Upcountry District technical conservation potential for indoor uses in a period of ten years.
- **Mitigation of Reductions in Wailoa Ditch base flows** - All strategies take into consideration and provide mitigation of reductions in Wailoa Ditch base flows resulting from implementation of amendments to the IIFS on East Maui streams.
- **Independent Components Considered in All Strategies** - A list of independent resources and plan components that could be implemented in any of the final candidate strategies was described in an earlier section of this report. It is presumed that these components would be included in any of the strategies but are not explicitly evaluated in the economic analyses or considered in the comparisons between the final candidate strategies.

General Characterization of Upcountry District Strategy Analysis

All of the strategies are designed to meet the water needs of the Upcountry District for the twenty five year planning period. Water need projections are based on the base case demographic projections that were prepared for and are being used in the current update of the Maui County General, Island and Community Plans.[3]

System Reliability and Expansion Criteria

In order to make meaningful comparisons of the economics of diverse resource strategies, it is necessary to apply system design reliability standards that are meaningful, consistent, specific and explicit. The objective of the economic analysis is to compare different approaches to providing water supply to meet projected needs over the planning period at a standard and consistent level of service reliability.

In order to ensure that sufficient and uniform water service capability and reliability is maintained it is necessary to consider at least two design criteria. First, it is necessary to maintain sufficient water sources to provide the amount of water required (water production capability). Second, it is necessary to maintain sufficient equipment and infrastructure redundancy to meet maximum production flow requirements even if some equipment is out of service (system capacity). The timing of the need for additional resources is determined considering both of these criteria. For purposes of long range planning and economic analyses, it is prudent to apply some conservative assumptions to account for uncertainties regarding efficacy of resources and possible delays in implementation.

For the DWS Upcountry District water systems it was necessary to develop system design reliability standards sufficient for purposes of meaningful planning and economic analysis. The surface water system design standards adopted collectively by the Hawaii municipal water departments are not sufficient for the analyses presented in this report. A set of standards was developed that addresses the mix of surface water and groundwater resources on the Upcountry District systems. Several standards were specified and used in the integrated capacity expansion and production cost model designed for the Upcountry systems. The standards were used in the modeling analysis to determine when new resource additions would be necessary to meet the growing demands on each subsystem. It was required that each of several standards would be met for each year of each analysis. In simplified form the determining standards used are:

- Drought Period Annual Water Availability: The calculated annual drought period surface water system capability (as determined by mass flow analysis) plus two thirds of the installed groundwater source capacity must exceed the projected annual design drought period production requirements on each subsystem allowing for boosting of water to upper systems limited by booster pumping constraints.
- Drought Period Day Production Capacity: The sum of the surface water treatment plant DOH rated capacities (rated filter flux with one independent unit out of service) plus two thirds of installed well pump capacity must exceed 1.5 times the design drought period average day production requirements on each subsystem allowing for boosting of water to upper systems limited to by booster pumping constraints.

These system design reliability standards are used to determine the dates that additional resources are necessary to ensure that each of the strategies provide sufficient and comparable levels of service reliability.

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3. Water demand projections are documented in detail in the *Water Use and Demand - Department of Water Supply Systems Chapter*, May 2007. These projections are based on the demographic projections in the Maui County Planning Department *Socio-Economic Forecast*, June 2006.

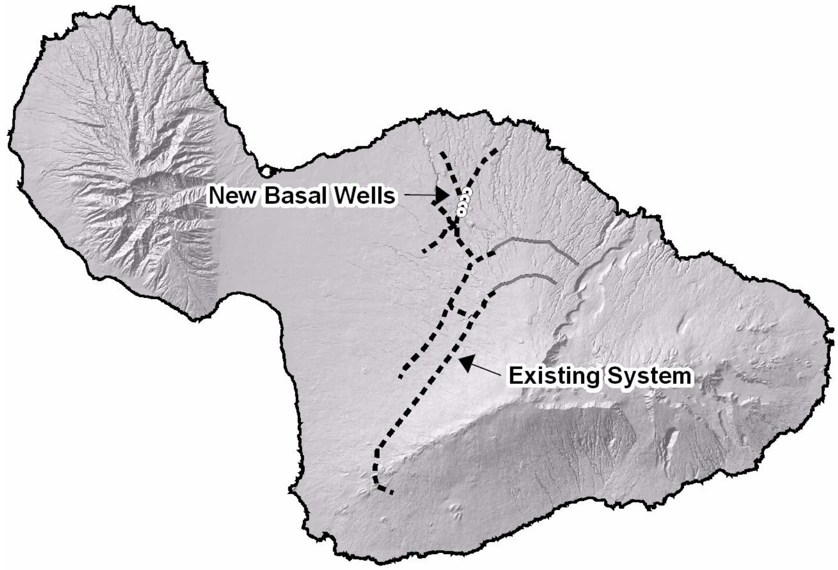
Iterative Analysis and Public Review

The analyses supporting this report were conducted in several iterative rounds.

- First Round - Presented to the Upcountry WAC on December 12, 2007
  - Resources that were characterized in the Candidate Strategies report were configured into more completely integrated strategies.
  - Characterization of the resource option components were updated. This included updating and refinement of energy costs, project capital costs and expected surface water system reliable yields.
  - Conservation and raw water storage reservoir options were examined in more detail.
- Second Round - Presented to the Upcountry WAC on February 13, 2008
  - Incorporation of comments received in presentations of the first round analyses to the DWS staff, the CWRM and the Maui County Board of Water Supply.
  - Upcountry drought reliability standards, system operation assumptions and capacity expansion criteria used in system modeling were examined and refined.
  - Water conservation program characterization and analysis was refined. A DSM program design consultant was retained to review the analysis methods and assumptions and to make recommendations for a portfolio of conservation programs for the Maui districts.
  - Additional options, variations and scenarios were examined for each of the final candidate strategies.
- Third Round - Presented to the Upcountry WAC on June 30, 2008
  - Economic analysis was presented for a range of possible future energy costs including recent higher energy costs.
  - A fifty year economic study period was added to supplement the twenty-five year planning period. This was provided to more thoroughly account for the long term operation cost benefits of some of the more capital intensive resource options (large water storage reservoirs and major water transmission systems).
  - Capital cost and depreciation accounting methods were refined.
  - Water conservation program characterization and analysis was further refined. A DSM program design consultant was retained to review the analysis methods and assumptions and to make recommendations for a portfolio of conservation programs for the Maui districts.
  - Strategies were refined based on updated information, comments received and ongoing review.
  - Additional strategy options were examined including an analysis of the Opana / Awalau water source and various wind power generation options.
- Fourth Round - Presented in this report
  - A range of energy price scenarios is presented.
  - Impacts and mitigation of Wailoa Ditch base flows were analyzed.
  - Uncertainties, contingencies and project implementation timing were analyzed.

A description of several more specific considerations and scenarios examined in the progressive rounds of analysis is provided in the discussion of the economic analysis for each of the final candidate strategies below.

In addition to the features and components explicitly considered in the analysis of the final candidate strategies there are several independent components (described in a section above) that can be considered for implementation with any of the final candidate strategies. These include measures that address county-wide planning objectives as well as measures to address DWS system objectives. For discussion of the independent components refer to the section above *Independent Components Considered in All Strategies*.



A. Incremental Basal Well Development

Summary

This strategy features development of new basal groundwater wells and associated tanks and booster pumps as needed to meet growing Upcountry District water demands. This strategy serves as the “reference strategy” to which other strategies are compared in the presentation of the economic analysis results in this report.

All of the implementations of this strategy include a portfolio of Demand-Side Management (conservation) programs that is designed to attain 45% of the water efficiency technical potential in a period of five years.[4]

Project Design Scenarios

Several project design alternatives were explored including variations in well elevations, pumping destinations and booster pump configurations. The analysis of alternate options examines wells installed at either of two elevations: (a) at 1300 foot elevation (pumping to the Kokomo tank) or (b) at 1800 foot elevation (pumping to the Pookela tank) as required by system needs. These generic well characterizations represent the range of possible basal well installations that could be implemented by the DWS or project developers. Booster pump upgrades were assumed to be installed as necessary to move water produced by these wells to the higher elevation systems as required.

Policy and Feasibility Considerations

Cost vs. Reliability vs. Sustainability

One policy matter that is common to all of the final candidate strategies is a balance between the objectives of minimizing cost, providing reliable water service and enhancing the sustainability of the system operations. The basal groundwater development strategy would incrementally pro-

4. The DSM program portfolio included in each of the final candidate strategies is described in a separate section on this subject and in Appendix A.

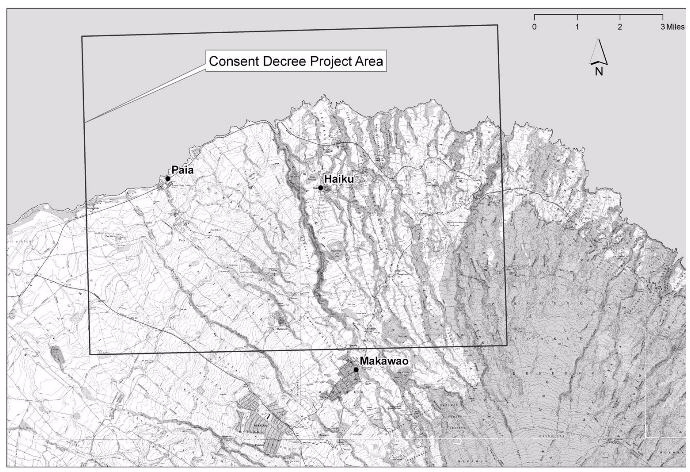
vide the drought period reliability associated with groundwater sources but at the cost of higher electrical power consumption required to pump water from the basal aquifer (near sea level) to the elevation of Upcountry District water uses. Assuming that groundwater withdrawals would be maintained within sustainable pumping yields, this strategy could be sustainable in terms of water source use but would commit the DWS system to increased electric power use.

Hydrology

The sustainable yield of the Upcountry District area is sufficient to provide new basal groundwater well development. Since basal wells are substantially more expensive to operate than available surface water production, it is expected that new basal wells would not operate at capacity except in the drier summer months and for more extended periods in drought years.

The efficacy and water quality of new wells in the Upcountry District is difficult to predict prior to drilling and testing. Wells drilled in relatively close proximity can prove to be very different in terms of effective production yields. Because of historical use of agricultural fertilizers and pesticides there is a possibility of contamination of source aquifer water in some areas.

Compliance with EMPLAN Consent Decree



The 1990 Maui County WUDP identified the development of wells in the Haiku aquifer (and associated water transmission) as a featured strategy to supply water to the Central District system. A concurrent East Maui Water Study was commissioned to develop this strategy. The draft 1992 WUDP update (never adopted) also featured this strategy as the primary means to provide new Central District water supply. The project, named the East Maui Water Development Plan (EMPLAN), moved forward with preparation of an environmental impact statement (EIS) and a supplemental EIS which were challenged in court. The court case was settled between the plaintiffs and the County by a Consent Decree.

The County is bound by a list of terms specified in the EMPLAN Consent Decree including the following:

- Only Phase I of the EMPLAN will be implemented until a completely new EIS is prepared. This includes construction of the Hamakuapoko wells and limited transmission connection to the Central District system.
- The County will not develop groundwater in an agreed upon portion of the East Maui region until a rigorous cost / benefit analysis is performed which shall, among other things, address planning for stream restoration in the agreed upon region.
- The County will “rigorously investigate and pursue the availability of surface water” from the Waikapu, Iao and Waihee areas including a rigorous cost / benefit analysis.
- Any new groundwater development projects in the agreed upon East Maui region will be consistent with the County WUDP and the State Water Code.
- The County will work with the USGS and plaintiffs to develop a test well to determine whether development of groundwater resources in the agreed-upon East Maui region would affect surface water resources in the region.

- As long term agricultural water needs are reduced, a stream restoration program will be studied, developed and initiated by the County.

Compliance with the terms of the EMPLAN Consent Decree would be necessary prior to development of wells within the EMPLAN area. This area is shown on the map above.

DWS versus Non-DWS Well Development Issues

Project Design, Construction, Ownership and Operation - DWS vs Developer

New basal wells could be constructed, owned and/or operated either by the DWS or by a project developer. Some combinations are possible. For example, a project could be designed and constructed by a project developer and, upon completion and testing, the ownership and operation could be transferred to the DWS.

It is presumed that, generally, a private project developer could install new wells in less time than the County. Several new well projects by developers in the Upcountry District are in various stages of design, drilling and completion.

New basal wells could be owned and operated by the project developer or transferred to a third party. If the well would not be operated by the County, the water produced by the well either would be sold to the County or would be distributed to users by an independently developed water transmission and distribution system. In order for a non-County entity to sell water directly to the general public (more broadly than to its owner-operators), it would have to become a public utility regulated by the Hawaii Public Utility Commission.

Project Capitalization

New wells could be financed by several methods. The County could provide all necessary financing. Financing could be provided by a project developer. Financing could be shared. Some of the financing (or project funds outright) could be provided by State or Federal sources.

The method of financing affects costs to the County and DWS customers. Clearly any financing or project funds provided by the State or Federal government could reduce costs to the County and DWS customers. Financing by project developers may reduce or may increase costs to the County and DWS customers depending upon the terms of contractual agreements. This is discussed further below.

Recent well projects by Upcountry developers have been financed by project developers. For wells that would be turned over to the DWS for ownership and operation, it is expected that the project developer would be reimbursed by the DWS by provision of “source credits”. Source credits are good towards payment of the source component of the System Development Fees due for obtaining water meters for future land development projects. It is not clear what entitlements or priority access to acquiring future water meters would be included in the contracts for transfer of the wells to the County. This is discussed in more detail in the section below.

Capitalization, Credits and Entitlements

Generally speaking, there are two distinguishable instruments of property created in contracts for developer financed water source projects.

SOURCE CREDITS

First is a “source credit” which is a “fiscal” credit good towards payment of the source component of the system development fee which is required to obtain a new water meter account with the DWS. Depending upon the terms of the applicable contract, source credits may or may not be tradable to other parties and may or may not expire at a determined date. Source credits can be denominated either in terms of a specified number of water meters (or meter equivalents) or in terms of a specified amount of dollars towards payment of system development fees.

ENTITLEMENTS

The second instrument created in contracts for source development is an “entitlement” to obtain water meters from the DWS upon demand and to obtain certification by the DWS director that the developer has provided or shown that there is a water source consistent with requirements of the County Code. Depending upon the terms of the applicable contract, any entitlements may pertain to specific land developments identified in the contract, may or may not be tradable and may or may not expire at a determined date.

Entitlements may be calculated or conjoined with source credits in the language of the contract terms but are nevertheless a distinguishable instrument of property and a distinguishable policy consideration. Source credits are a financial instrument good towards payment of a future source development fee. Entitlements are an obligation by the DWS to provide a DWS water meter (and/or a “verification” of availability of water source) upon demand of the holder at some future date.

The source credits and entitlements created in source development contracts are both real DWS liabilities. Although these liabilities are not documented in DWS standard accounting reports they are necessary to consider in the economic assessment of the candidate resource strategies. The disposition of source credits is necessary to consider in the calculation of DWS capital costs, depreciation and debt service. Entitlements are important to consider in determining applicability of the resource capacity and water production to meet projected system water demands.

In the analyses presented in this report it is presumed that the capacity and production capability of a resource financed by a source developer by contract will be available to meet projected DWS system water demands. It is also presumed that capitalization of new sources would be financed by the DWS. If new water sources are financed by a source developer by contract with the DWS it is probable that a different stream of costs would result.

From the perspective of the County, the DWS and its customers, the costs or benefits of private developer project financing depend upon specific contract terms, particularly the terms that specify how the source credits are to be denominated. Source credits are credits towards payment for the source component of DWS system development fees. Source credits are most often denominated in terms of a specified number of water meters (or 5/8" water meter equivalents) or a specified number of gallons per day credit towards land development requirements. These means of denomination are also typically applied to contractual water entitlements.

As an alternate approach, source credits could be denominated as a specified number of dollars credit towards system development fees charged for new water meters. This would have two advantages for the DWS. First, it would ensure that, if source development fees increase, the value of the source credits would not appreciate at the expense of other new DWS customers. Second, if source credits are tied to the costs of development of new sources, this would remove the incentive for source developers to develop only the cheapest sources. This would remove any disincentive for source developers to provide sources desired by the DWS that might be more expensive, on a capacity unit basis, in terms of capital costs.

Several scenarios regarding alternate project capitalization arrangements were analyzed to determine the relative costs and benefits to the County and DWS customers. If a project would be financed half by the project developer and half by the DWS, the County (and DWS customers) would save about 13% compared to full DWS financing assuming that the cost of the DWS system development fees does not increase.[5] If the DWS system source development fees

5. This analysis also assumes that the source credits would be denominated as a specified number of meters (or meter equivalents) and that the source credits would be used at the same rate as general development growth in the overall system.

increase, developer financing could be more expensive to the County and its customers than full DWS financing.

The relative costs and benefits of developer versus DWS financing of different projects may be very different for any of several reasons. One factor is the fact that the project costs are not necessarily a direct function of project production capacity, whereas the source credits are typically denominated in terms of project production capacity. In other words, the value of a source credit to the developer (and the equivalent liability to the DWS) is not directly related to the project cost. Another factor is that the value of the project to the DWS system is not always directly related to the project production capacity or its capital cost. For example, a source that is expensive to operate is not as valuable to the DWS as a source with equivalent capacity that is economical to operate. Reliable reservoir system capacity is more valuable for the Upcountry system than drought backup well capacity.

From a policy standpoint, it is important to keep in mind that when a project developer “pays” for all or some portion of a project and receives source credits towards system development fees, the developer is really only providing financing for the project, not funding the project. The potential benefit to the DWS and its customers is the savings that accrue from having to borrow less money to build the project. This benefit is offset by the decreased stream of revenue from system development fees when source credits would otherwise be redeemed. The extent to which project developer financing ultimately is a benefit or a cost to DWS customers depends upon a number of factors including the rate at which the source credits are used, how the source credits are denominated and whether system development fees increase in the meanwhile.

One particularly important aspect of water entitlements for source project contracts on the Upcountry District systems is the backlog of unserved need for new water meters. A waiting list for new water meters for the Upcountry District has been established to allocate new incremental water production capacity to prospective customers. Allocation of new production capacity between new water services for a water source developer and water services for prospective waiting list customers is an important contractual and policy determination. This allocation would be negotiated between a water source developer and the DWS with contractual terms subject to review and approval by the County Council.

<u>Well Siting</u>

When the DWS develops a new well it considers several criteria to determine the optimal well location. When a non-DWS entity develops a well, the DWS has substantially less control over the well location. Important well siting considerations include:

- proximity to the DWS system main transmission pipes
- proximity to DWS customer demand location
- well elevation and need to boost water to DWS users
- possible well contamination from historical agricultural chemical or other commercial or industrial chemical contaminants
- the extent of needs for future wellhead protection

A recommendation of this report is to establish prospective well siting policies and/or well development zones as regulatory measures to ensure optimal location of wells that will become part of the DWS systems.

<u>Integration of New Wells with the DWS Systems</u>

Development of new basal wells in the Upcountry District must be incorporated into the operation of the DWS water system. New water sources should be consistent with the planning and operational needs of the DWS systems. Currently the Upcountry DWS systems need new sources to provide drought period production reliability as well as sources to provide economical water production. Depending upon the overall system development strategy and what future resources are added to the Upcountry water systems, the needs for different types of water sources may change. It is important that sources provided by non-DWS developers are consistent with the resource needs and fit appropriately into the operation protocols of the Upcountry systems.

Interconnection with the Central District System

One candidate strategy that was considered was interconnection of the Upcountry and Central District systems. Generally, interconnection of systems can provide potential mutual benefits. As originally conceived, interconnection of these systems could provide backup capacity for each system and possible economic benefits. Proponents posited that the groundwater sources of the Central system could provide water to the Upcountry system in times of drought and the surface water sources of the Upcountry system could provide an economical source of water for the Central system when water is plentiful. Investigation of this strategy, however, showed that interconnection, by itself, would not eliminate the need to provide new sources of water for both systems. Central resources are already too constrained to provide water to the Upcountry system for any extended periods of drought. The opportunities available to use surface water sources to provide economical water supply to the Central system are limited. The costs of interconnection are high due to the high costs of extensive transmission line construction. Interconnection could provide incremental value to both systems to the extent that this is possible without major transmission line construction. One opportunity would be limited interconnection along Baldwin Avenue where distribution lines from the two systems are in fairly close proximity. Another option would be possible if there would be transmission extensions from the Central District system to develop sources in the Haiku aquifer. This is discussed briefly below.

DUAL PURPOSE SERVICE OF HAIKU AQUIFER BASAL WELLS

One of the final candidate strategies for the DWS Central District is development of a series of wells at approximately 1000 foot elevation in the Haiku aquifer with new transmission to the Central system. Implementation of this strategy would provide a relatively inexpensive means to interconnect the Upcountry and Central systems due to the proximity of substantial capacity transmission piping.

Interconnection could provide a limited amount of additional redundancy of production equipment for the Upcountry system with the addition of sufficient additional booster pumps. This is of limited value, however, since the Upcountry system is not limited by equipment redundancy but is limited instead by drought period source water availability. (With the exception of booster pump capacity, the Upcountry system already has sufficient equipment capacity redundancy). New resources planned for the Upcountry system are necessary to provide a reliable source of water during times of low production capability of the surface water sources during periods of drought.

Interconnection would not provide substantial new drought period source water capability for the Upcountry system. The Haiku wells are relied upon in the Central District strategies to provide new effective source water production for the Central system. For periods of short duration, other water sources on the Central system could provide supplemental production to make up for water that would be required from the Haiku wells to meet upcountry needs. This would not be possible, however, for moderate or extended drought periods which typically last several months per year.

Interconnection could also provide economic benefits during times that ample water is available in the Wailoa ditch (supplying the Kamole WTP) that could serve the Central system and displace more expensive Central system resources. The costs of expanding the Kamole WTP for this purpose, however, exceed these system operation efficiency benefits (even without considering the costs of necessary interconnecting transmission improvements). It would not be economical to use treated water from the Lower Kula system or Upper Kula system to serve Central system needs. This would be possible only during wet winter months with ample surface water source flows and when upcountry storage reservoirs are full. These times tend to coincide with periods of minimum demand and lowest production costs on the Central system.

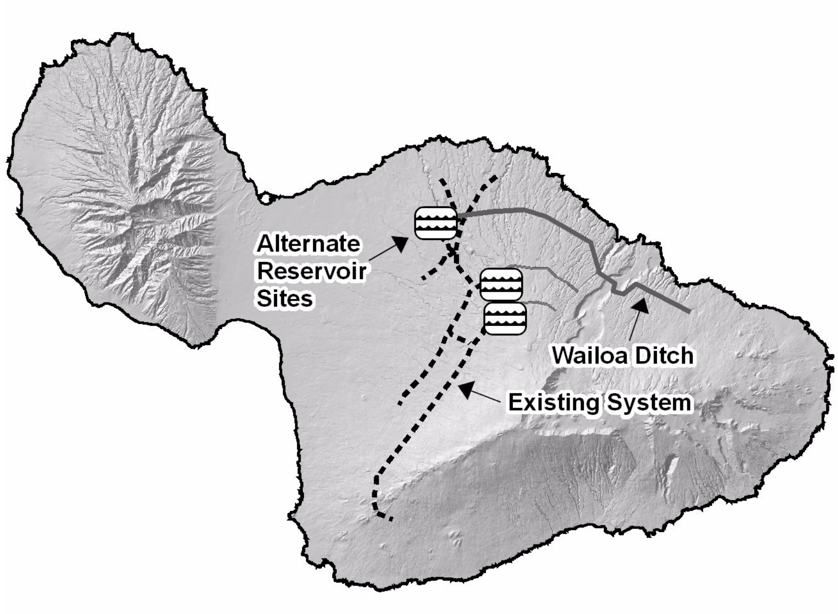
Although there are benefits to interconnecting water systems, interconnection of the Upcountry and Central systems would not, in itself, avoid the need to develop new water sources for both of these systems. Interconnection could provide a limited amount of additional redundancy in system capacity (equipment) but both systems are in need of new sources of water to meet growing water demand.

Economic Analysis

Economic analysis of the Incremental Basal Well Development strategy was presented in the Candidate Strategies Chapter and previous presentations to the Water Advisory Committee. The updated economic analysis of this strategy is presented in this report in the sections below that examine the other final candidate strategies. The Incremental Basal Well Development strategy is used as the reference strategy in the following sections which examine the economics of the alternate final candidate resource strategies.

In all of the charts below showing the results of the economic analyses presented in this report the Incremental Basal Well Development strategy serves as the reference strategy to which the other strategies are compared.

See the discussion in the Economic Analysis section of the Expanded Raw Water Storage final candidate strategy below for discussion of the economic modeling and analyses presented in this report.



B. Expansion of Raw Water Storage Capacity

Summary

This strategy features one or more new raw water storage reservoirs to supplement the effective reliable yields of the existing Upcountry District surface water treatment systems. Additional reservoir storage capacity increases the drought period reliable yield of the surface water collection, storage and treatment systems and provides increased volumes of economical surface water.

Large new storage reservoirs require substantial up-front capital investments that yield long term benefits in reduced system operation costs. The optimal capacity of raw water storage for each system is a function of the amount of water and the streamflow characteristics of the streams that feed the reservoirs on each system and the capacities of the stream diversions and transmission pipes that bring the diverted water to the reservoirs. Optimal reservoir capacity is different for each system.

Reservoirs of various capacities were analyzed for the Upper Kula, Lower Kula and Makawao subsystems. The Lower Kula system and the Makawao system (Kamole WTP) are most in need of additional raw water storage.

Additional reservoir capacity on the Lower Kula system provides operational economy by reducing system pumping energy requirements and optimizes drought period service reliability considering the flow characteristics of the tributary streams. The optimal size for new reservoir capacity on the Lower Kula system is in the range of 100 to 300 million gallons. Environmental constraints are an important consideration and may limit the location of a new reservoir on the Lower Kula system to areas near or to the west of the existing Piiholo Water Treatment plant.

Additional reservoir capacity on the Makawao system serving the Kamole WTP could mitigate reductions in source water base flows resulting from existing and anticipated amendments to the instream flow standards on tributary East Maui streams. The optimal size for new capacity on the Makawao system is in the range of 100 to 200 million gallons depending on the ultimate magnitude of base flow reductions.

The final implementations of this strategy include a portfolio of Demand-Side Management (conservation) programs that is designed to attain 45% of the water efficiency technical potential for indoor uses in a period of ten years.[6]

Project Design Scenarios

Functional Design Objectives

Additional raw water storage reservoir capacity serves two discernible functional objectives for the Upcountry District systems.

- First, additional reservoir capacity can provide an economical source of additional reliable water service production and capacity to meet existing and growing water demands.
- Second, additional reservoir capacity can serve to mitigate anticipated decreases in base flows available to the Kamole WTP resulting from amendment of interim instream flow standards to return water to East Maui streams.

These two functional objectives are addressed both independently and conjunctively in this report in several sections:

- Appendix C of this report describes and presents several analyses including examination of the Koolau/Wailoa ditch system historical flows, the impacts of various levels of base flow reductions on the drought period reliable capacity of the Kamole WTP and the effectiveness of various raw water storage reservoirs to mitigate reductions in source water base flows.
- In the final candidate strategy section below, "*D. Improved Kamole Water Treatment Plant Capacity"*, the use of basal wells versus various sizes of raw water storage reservoirs to serve the Kamole WTP are examined and compared as a means to mitigate various possible source water base flow reduction scenarios.
- In this section, "*B. Expansion of Raw Water Storage Capacity"*, various potential additional raw water storage reservoirs are examined more broadly. The optimal capacities, locations (Upper Kula, Lower Kula or Makawao subsystems) and combinations of reservoirs are examined as an economical means to provide reliable water service capacity to meet existing and growing water demands.
- In the section "Comparison of Final Candidate Strategies" all of the strategies are compared and analyzed considering contingencies and project implementation timing constraints.

Reservoir Size and System Location

Several variations of this strategy were analyzed to determine the optimum size and system location for new raw water storage reservoirs. Reservoirs sized from 30 to 500 million gallons were analyzed for the Upper Kula, Lower Kula and Makawao subsystems. Mass flow analyses were developed for each system based on historical daily streamflows to determine the drought period reliable yield of various reservoir sizes. The economics were then examined using the integrated capacity expansion and production cost model. The results of these analyses have been presented previously in the Candidate Strategies Chapter and in presentations to the Water Advisory Committee. Some of the results are provided below in the discussion of economic analyses.

Reservoir and System Operation Objectives

A reservoir and water treatment plant system can be designed and operated to provide several types of benefits for the DWS water systems.

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6. The DSM programs included in each of the final candidate strategies is described in a separate section on this subject and in Appendix A.

Design and Operation for Maximum Reliable System Capacity

A surface water storage and treatment system could be designed and operated to optimize the amount of reliable capacity provided to the DWS water system. The operation of the system would prioritize maintaining substantial reservoir levels to ensure adequate water supply during potential extended durations of low stream flows. A primary benefit of operating a reservoir to maximize reliable capacity would be deferral of other capital improvements that would otherwise be necessary to provide equivalent reliably capacity.

Design for Reducing Groundwater Withdrawals and Water Pumping

An alternative objective of surface water system design and operation would be maximization of treated water use to provide economical water supply and reduce expensive pumping and groundwater withdrawals. The operation of the system would maximize production of treated water whenever water is available in the reservoir. A benefit of this operational protocol would be reducing electric power costs and reduction of groundwater withdrawals.

Maximizing reservoir capacity is consistent with furthering either or both of the operation objectives identified above. The cost effectiveness of providing ample reservoir storage, however, depends on different factors in each case. Several alternate reservoir operating protocols were examined in the analysis of the economics of Upcountry District raw water storage options.

Financing Alternatives

The costs of providing additional raw water storage reservoir capacity are primarily capital costs for construction of the reservoir. The economic analyses presented in this report presume that the cost of a new storage reservoir would be provided by the County and ultimately by DWS water system customers.

In the integrated economic analyses presented in this report, water storage reservoir capital costs are amortized over the expected service life of the reservoir, assumed to be 100 years. This treatment is appropriate for long term life cycle cost analysis. Short term DWS financial impacts and rate impacts on DWS customers, however, would be more extreme than what is depicted in the near term annual cash flows indicated by this approach. Characterization of near term financial and rate impacts must be analyzed separately.

The feasibility of financing for the larger raw water storage reservoirs considered in the final candidate strategies must be assessed as an issue in addition to the life cycle cost effectiveness of the candidate strategies. Federal or state funding or financial support may be necessary for these projects to be feasible. To the extent that federal funds are provided or low interest financing is available, the life cycle costs to the County and DWS customers would be less than portrayed.

Opana / Awalau Source Analysis

A diversion in the Opana stream at an elevation of 2400 feet routes water through a tunnel to the Awalau stream area. A collector box distributes water from the tunnel and an Awalau spring to pipes serving several users including the DWS. Prior to the Clean Water Act water treatment requirements, this source supplied water to the Maluhia tank on the DWS potable water system. Currently, the majority of the water from this source feeds a 10 million gallon reservoir serving and managed by a partnership of agricultural users. A minor portion of non-potable water is provided to existing DWS customers.

The Opana/Awalau water source was evaluated as a potential resource option as a source for treatment to supplement DWS potable uses. Several options were evaluated. These analyses are described in the Economic Analysis section below.

Policy and Feasibility Considerations

Cost vs. Reliability vs. Sustainability

The final candidate strategies differ from one another regarding the balance between the objectives of minimizing cost, providing reliable water service and enhancing the sustainability of the system operations. The Expansion of Raw Water Storage Capacity strategy would require large initial capital expenditures that would reduce future energy consumption and system operating costs. This strategy would provide incremental increases in Upcountry District system service reliability but would not, by itself, provide the same drought period reliability as groundwater development strategies. Overall, additional raw water storage capacity would contribute substantially to a balance of the objectives of minimizing long term system costs, increasing system reliability and promoting sustainability.

With the strategies that incorporate the addition of raw water storage reservoirs there is a trade-off between near term drought period reliability and long term cost effectiveness. The analysis presented in this report indicates that the most economic and sustainable strategy may be to provide raw water storage for the Upcountry system instead of relying on extensive additions of basal groundwater wells which require high long term energy expenditures. There would be an extended period of time, however, before one of more storage reservoirs can be installed. The most economical approach might be to commit to a strategy that incorporates water storage reservoir(s) and maintain the existing level of system reliability until the reservoirs are commissioned. If a substantial number of basal wells are added to the system prior to commissioning the reservoir(s), this would enhance near term system reliability (and perhaps allow more meters to be issued) but would diminish the long term economic advantage of a storage reservoir strategy.

Budgeting for Project Capital Costs

The economic analyses presented below indicate that additional raw water storage reservoir capacity is cost effective considering long term Upcountry District system capital and operating costs. Even though reservoir construction may be economical considering long term levelized costs, the need for budgeting the large necessary capital requirements for reservoir construction presents immediate challenges, especially in the current economic climate. Funding needs must also consider the capital requirements of other DWS Districts.

Agricultural vs. Municipal Service Objectives

Raw water storage to meet drought period water demand is necessary to meet both domestic and agricultural needs. These objectives may conflict with one another in drought periods as growth in Upcountry District system demand challenges the sufficiency of the finite supply of economical surface water. Even with substantial increases in the amount of raw water storage the supply of surface water on the Upcountry District system is limited to the source streamflow and collector system capacities.

The 100 million gallon Kahakapau reservoir addition to the Upper Kula system was constructed with substantial federal funding targeting agricultural water service needs. The existing use of the reservoir serves both domestic and agricultural needs. A new non-potable water line has been constructed that would draw water from the Kahakapau reservoir bypassing water treatment at the Olinda water treatment plant to serve agricultural needs of the Upper Kula system area. The water demand projections used in the analyses presented in this report presume that when non-potable water becomes available from the agricultural water line this will displace the use of potable water that is now use for agricultural purposes. Depending on the pricing and policies regarding the drought period availability of water from the non-potable line, however, agricultural uses may increase beyond what is assumed.

To the extent that water from any new raw water storage reservoirs in the Upcountry District is restricted in drought periods, allocation of water between agricultural and municipal uses will present a challenging policy issue. This potential allocation issue should be considered when the sources of funding for new reservoir construction are determined.

Environmental Impacts and Reservoir Location

The location of any new raw water storage reservoir in the Upcountry District must consider associated environmental impacts. The water sources for the Upper Kula and Lower Kula sub-systems are located in areas that are particularly sensitive environmentally. Environmental impacts are dependent upon reservoir location and include both on-site impacts and impacts associated with access roads and staging of reservoir construction.

Consideration of environmental impacts includes policy issues, viability issues and cost issues. As a matter of policy, environmental impacts should be considered as one of the determining factors in deciding whether construction of new reservoirs is the best strategy. Environmental permitting requirements must be considered in determining whether new reservoir construction is viable. Location-specific environmental impacts also affect costs associated with mitigation of environmental impacts.

Early in the process of reservoir siting and design the DWS should establish a constructive dialog with the requisite permitting agencies to assess issues and potential environmental costs and proceed accordingly.

Continued Use of Water Diverted from Streams

Additional raw water storage capacity represents an extended commitment to using water diverted from streams. This should be considered in conjunction with the planning objectives of restoring water to streams and supporting culturally important resources. Diversion of surface water also affects discharge of fresh water to the ocean, which may affect fishing resources and the marine environment.

To the extent that water currently diverted from East Maui streams may be returned to the streams by amended instream flow standards established by the CWRM, the long-term availability of diverted water for municipal uses may be abridged. Recent and further anticipated amendments to the interim instream flow standards for East Maui streams will require mitigating actions to maintain the historical drought period reliability of the Kamole WTP.

Economic Analysis

Economic analysis of the final resource strategies was performed using an integrated resource analysis model that was configured for the Upcountry District system. The four Upcountry District subsystems (Upper Kula, Lower Kula, Makawao and Haiku) were modeled individually but interactively taking into consideration the water demands of each subsystem, the production resources of each subsystem, and the ability, economics and necessity of water transfers between the subsystems.

Water transfers between subsystems are modeled based on economics (when providing water from an another subsystem is less expensive considering any pumping or transfer costs) and based on need (when water needs on a subsystem cannot be met by resources on that subsystem). Transfers between subsystems take into consideration limitations on booster capacity. Booster capacity is added in a future year if and when this becomes necessary. The variable and fixed operating costs (and the capital costs of additional needed booster capacity) of transfers between subsystems are calculated and accounted in the total system costs.

The Upcountry District subsystems are modeled sequentially for each year of the analysis in both average and drought conditions. This is important because of the sensitivity of the surface water subsystems to both average and drought period conditions and because drought period production capability is important in determining the dates that additional production resources are needed to maintain system reliability.

Reservoir Reliability and Economic Analysis

Several of the final candidate strategies presented in this report have differing characteristics regarding service reliability, capital versus operation costs and reliance on electrical power for pumping. Generally, strategies relying on surface water sources are more susceptible to drought period reliability deficiencies than strategies that rely upon groundwater sources. Additional raw water storage reservoirs are capital intensive whereas groundwater production sources have substantial long term operating costs, primarily for electrical energy for pumping. Meaningful comparison of the these differing strategies must properly account for incremental contributions of each strategy to water system service reliability and must provide proper accounting of future streams of capital versus operating costs.

The approach used in the analyses presented in this report includes several phases:

- Mass flow analysis of historical streamflows, anticipated reductions in stream base flows and collection system and treatment plant characteristics to determine incremental contribution to system service reliability in drought period and normal conditions for various assumed reservoir capacities for each Upcountry subsystem.
- Estimates of costs of various raw water storage reservoir options.
- Integrated analysis of the operation of the Upcountry District water system and subsystems in drought period and normal conditions.
- Comparisons of the economics of different strategies assuming maintenance of equivalent service reliability.

The economic analysis of the Expansion of Raw Water Storage strategy was conducted in several iterative rounds. Initial analysis focused on determining the optimal additional reservoir capacity for each Upcountry District subsystem and comparison of the value of additional reservoir capacity between systems. These analyses were then refined regarding several factors including reservoir operation protocols, integrated operation of subsystems, characterization of drought versus normal period assumptions, anticipated impacts of reductions in source base flows and consideration of a range of assumed electric power costs.

Alternate assumptions regarding reductions in base flows available to the Kamole WTP were incorporated in several rounds of analysis. First, analyses are presented for various reservoir addition options independent of anticipated reductions in base flows (presuming that reductions would be mitigated by other means). Further analyses are presented evaluating various combinations of reservoir additions in conjunction with mitigation of alternate possible base flow reduction scenarios.

Alternate assumptions regarding possible future power costs were incorporated in several rounds of analysis. In the analyses presented in this report strategies are characterized for two alternate electric power cost scenarios representing lower and higher future energy prices.

All of the analyses in this section focus on system economics irrespective of specific constraints on project timing and phasing. Analysis considering project timing constraints is presented in the later section of this report: “Comparison of Final Candidate Strategies”.

Presentation of Results of the Economic Analysis

The results of the economic analyses are presented in charts that show the net present value of total DWS Upcountry District system costs over a twenty-five year planning period and a fifty year study period.[7] The charts show the net present value of the following cost categories for each of the strategies:

- Variable Operating Costs - These are operating costs that vary as a direct function of the amount of water produced by each of the resources in the analysis in each year of the study period. These are primarily energy costs and costs for purchase of source water where applicable.
- Fixed Operating Costs - These are operating costs that change with the addition of new resources but are not directly affected by the amount of water produced by each resource. These costs include the costs of maintaining and operating the existing system and new resources as they are added to the system, including labor, and an apportioned share of DWS administrative operations and repair expenses.
- Capital Costs - These are the amortized capital carrying costs of the Upcountry District system, including capital carrying charges (interest and depreciation) for new resource assets and depreciation and replacement costs for existing system assets.
- DSM Costs - These are the total costs of implementing demand-side management (water conservation) programs, including the full measure and installation costs (whether born by the program participant or by the utility and including any utility incentives) and costs to administer the programs.
- Total Costs - These are the sum of the four categories of costs listed above.

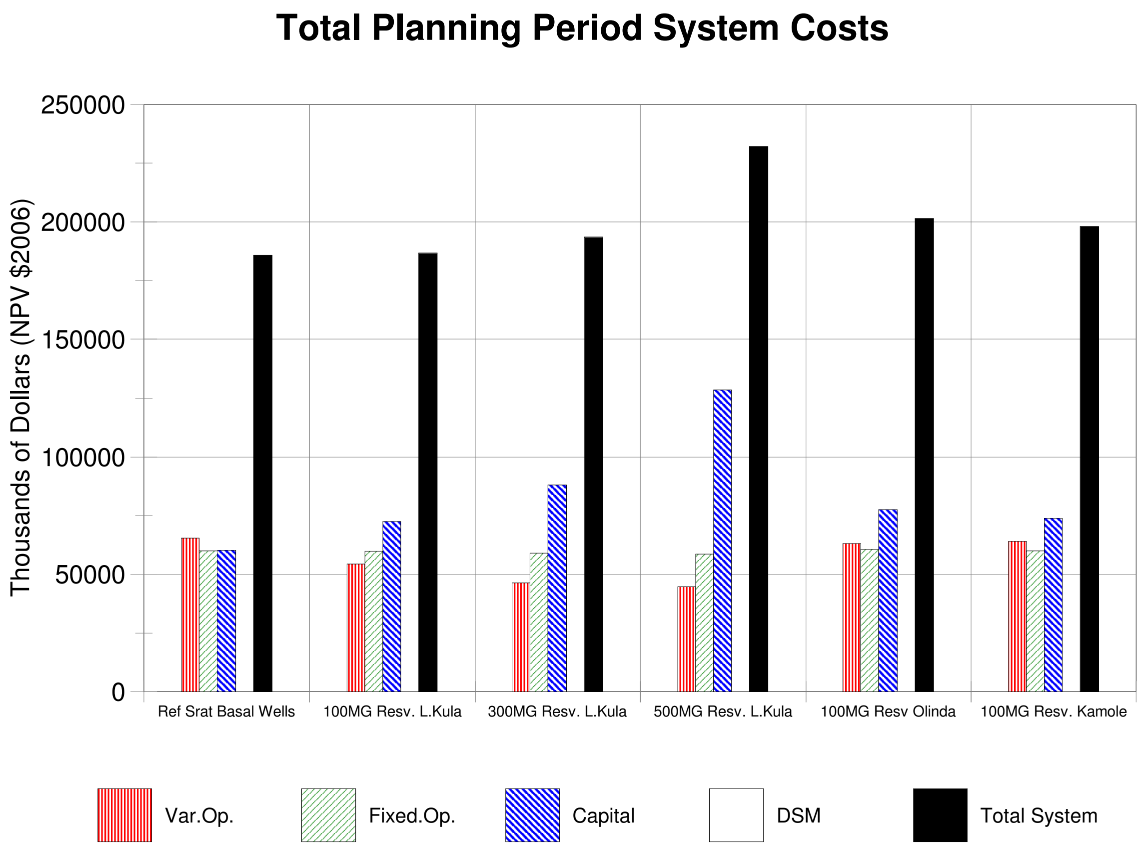
The first chart shows the total costs for the DWS Upcountry District system for the fifty year study period. Later charts show the same data presented as differences for each cost category for each strategy compared to a reference strategy. This format focuses on the differences between the strategies and makes differences easier to see. It is important to remember, however, that the costs represent total DWS system costs, not only the costs of the featured resources in each strategy.

The first strategy at the far left of each chart is the "Reference Strategy". This strategy provides the "zero point" for all of the charts that present costs as differences from the reference strategy. In all of the charts presented in this report the reference strategy in the first (left most) column is the Incremental Basal Well Development strategy. This provides a means to compare the analysis of each final candidate strategy with a uniform standard.

Generally, at least two charts are presented for each set of strategies showing alternate energy cost scenarios. During the time in 2008 that several rounds of analysis of the final candidate strategies where presented to the Water Advisory Committee, the cost of electrical power changed dramatically. Crude oil prices increased from about $60 per barrel at the beginning of 2008 to $140 per barrel in the Spring and then decreased again to less than $40 per barrel. Energy costs are a significant component of the total costs of the DWS system. In order to consider the uncertainty regarding future energy costs a "low" energy cost scenario (starting at $75 per barrel) and a high energy cost scenario (starting at $125 per barrel) are presented for each set of candidate strategies. In each scenario energy costs are assumed to increase at a rate 1% higher than the rate of general inflation.[8]

7. The twenty-five year planning period includes the years for which future water demands are projected and system resource additions are optimized to meet demands reliably. The fifty year study period includes an additional twenty-five year extension period in which future capital and operating costs are projected based on the status of the system in the last year of the planning period and appropriate assumptions regarding long term cost escalation. This additional extension period provides a more reasonable assessment of the long term benefits of capital improvements (and associated expenditures) made in the study period that would defer a long term stream of future operation costs.

8. In addition to the analyses presented in this report several alternate assumptions regarding future energy prices were examined.



Alternate Upcountry Reservoir Locations and Capacities
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

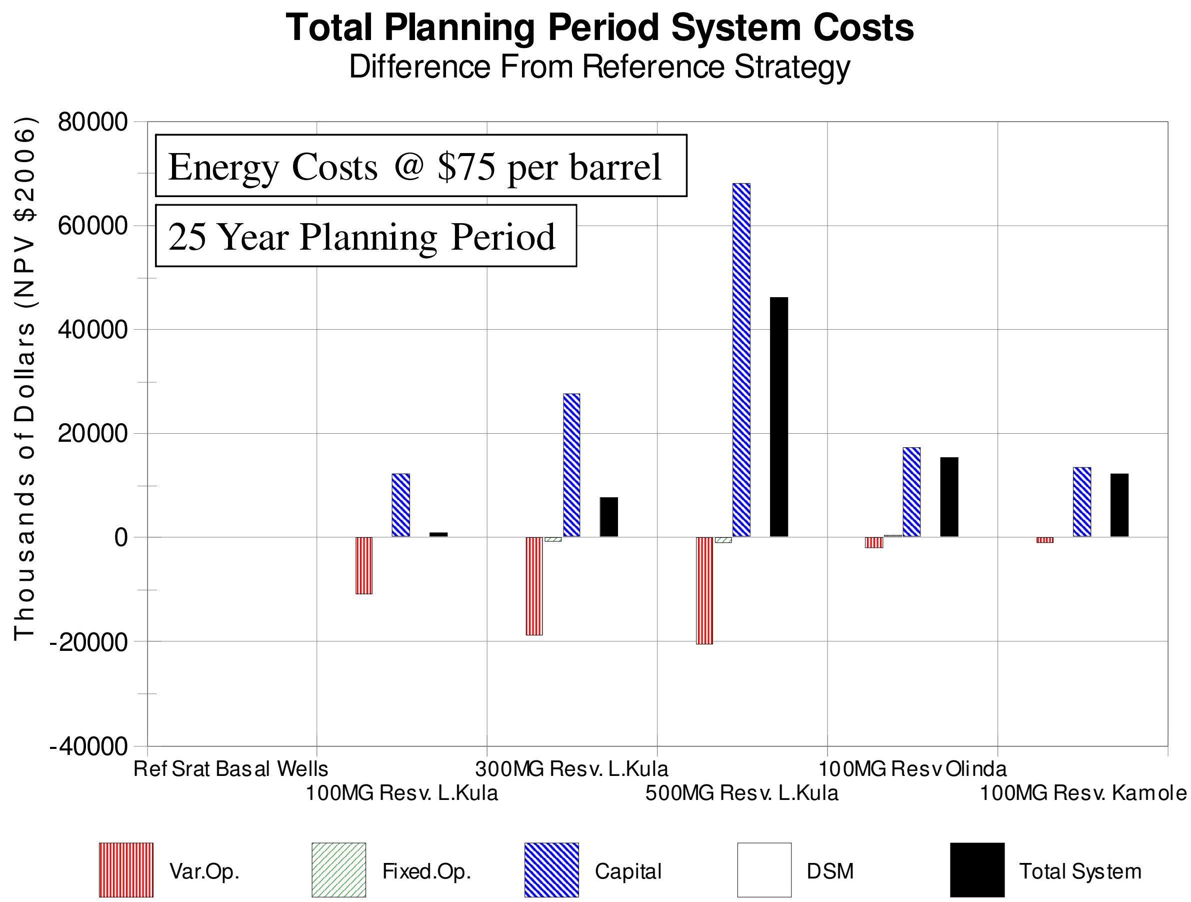
Alternate Reservoir Locations and Capacities

The chart above shows the net present values for the DWS Upcountry District system over a 25 year planning period (2005 - 2030). The left most column is the Incremental Basal Well Development strategy (Reference Strategy). The other five columns show total system planning period costs assuming the construction of raw water storage reservoirs. Three columns show 100 MG, 200 MG and 300 MG reservoirs on the Lower Kula System. The two columns on the right show 100 MG reservoirs on the Upper Kula system (Olinda) and Makawao system (Kamole). This particular analysis does not include DSM (conservation) programs in any of the strategies depicted.

All of the strategies depicted presume that any reductions to historical flows available to the Kamole WTP will be mitigated by other means (development of additional basal wells or separate raw water reservoir capacity at Kamole WTP). The 100 MG reservoir at Kamole strategy accounts only for the additional reliable capacity provided by source flow characteristics and does not consider other improvements to Kamole WTP reliable capacity discussed in section *D. Improved Kamole Water Treatment Plant Capacity*.

Variable operating, fixed operating and capital costs are all substantial components of total costs in all strategies. The strategies that include construction of large raw water storage reservoirs have substantially higher capital costs (associated with reservoir construction) and lower variable costs (from lower electric power costs for pumping).

The differences between the cost components of the strategies is discernible in this chart but is more clearly seen in the following chart that shows the same data presented as differences with respect to the Reference Strategy shown at the far left.



Alternate Upcountry Reservoir Locations and Capacities
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same data as the previous chart except all costs are portrayed as differences from the Reference Strategy costs at the far left. The higher capital costs and lower variable costs of the strategies that incorporate large storage reservoirs is clear.

This analysis examines costs for the 25 year planning period assuming the low energy cost scenario (energy prices starting at $75 per barrel crude oil price equivalent escalating at 1% per year above the cost of general inflation). Several charts below examine the same set of scenarios considering a longer 50 year study period and alternate energy cost assumptions.

RESERVOIR LOCATION

In all of the analyses that compare alternate reservoir locations (in terms of which system the reservoir is located) without regard to mitigating reduced base flows available to the Kamole WTP[9] the most cost effective location is on the Lower Kula system.[10] In the chart above, this is

9. All of the strategies depicted in the chart above presume that anticipated reductions in base flows available to the Kamole WTP are mitigated by other means (provision of basal wells or separate raw water storage capacity)

shown by comparing the 100 MG reservoir strategies for each system. For the Lower Kula system (2nd column from the left) the total system costs are slightly higher than the reference strategy (as shown by the black total cost bar slightly above zero). For the Upper Kula and Makawao system (two columns a the far right) the 100 MG reservoir strategies have substantially higher total costs than the reference strategy. This is a result of several contributing factors including the streamflow and collection system characteristics, the demand requirements and the elevation of each system, as well as the resulting interactive economic opportunities and service demand needs for transfers of water between systems. Primarily, the Lower Kula system has more source water availability, more subsystem demand and less existing reservoir capacity than the Upper Kula system.

The benefits of adding storage to serve the Kamole WTP depicted here are relatively small. Note that this analysis of a reservoir at Kamole WTP strategy only examines reservoir reliability benefits presuming that anticipated reduced flows to the Kamole WTP are mitigated by other means. As shown in analyses presented below, a reservoir at the Kamole WTP site **is** a cost effective strategy to mitigate anticipated Wailoa Ditch base flow reductions.

The historical flow characteristics of the Koolau/Wailoa ditch system that serves the Kamole WTP are already "regulated" by the water storage capacity of the large watershed area that contributes to the base flow of the extensive system of contributing streams. Under these historical water flow conditions, relatively large reservoir capacity would be required to substantially increase the drought period reliable capacity of the Kamole WTP. Also, additional storage on the Makawao system would not provide substantial economic benefits (compared to the Upper Kula and Lower Kula systems), since water would need to be boosted to the upper systems in drought periods. Considering substantially reduced base flows in the Koolau/Wailoa ditch system, however, raw water storage reservoir capacity becomes necessary to provide reliable capacity in dry or drought periods.

RESERVOIR CAPACITY

The optimum capacity for water system source storage is a function of several factors including the source water streamflow characteristics, system water demand characteristics and economics. If a water source is constant with no variation in flow and water demands are constant, there would generally be no need for source storage capacity. If a water source is "flashy" or is dry for some periods of time (like the Upper Kula and Lower Kula sources) then storage reservoir capacity is important to provide a reliable way to meet persistent water demands. Adding reservoir capacity increases system reliable service capability... but only to a certain point and with diminishing returns. Clearly, no matter how large a reservoir is provided, the average output of a water system cannot be greater than the average source input. The optimal reservoir size, considering the diminishing returns for progressive increases in reservoir capacity depends upon economics. At some point the costs of progressive additional reservoir capacity are not justified by diminishing incremental system reliable output.

The economic analyses of water storage reservoirs in this report are based on mass flow analyses that consider the historical (and anticipated) daily source flow characteristics and simulation of reservoir levels over extended periods of time to determine system reliable output for various reservoir configurations. The economics of various reservoir configurations depicted in the charts shown here are determined the integration model examining the operation of the whole Upcountry District water system over an extended planning period (twenty five years) and study period (fifty years).

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10. The analysis of reservoir location here considers only on which system a reservoir would be located. No specific sites were presumed or evaluated. It is presumed that any reservoir would be located somewhere between the existing source diversions and the existing water treatment plants at the elevation (hydraulic gradient) of the water transmission system. Cost estimates for reservoir construction are broad generic estimates that are not site specific.

Several reservoir capacities are shown in the chart above for the Lower Kula system. The diminishing returns in progressively larger reservoir capacities are shown by smaller reductions in system variable costs with progressively larger reservoir capacities. The chart above indicates that the optimal reservoir capacity would be 100 MG when considering the 25 year planning period and assuming the low energy cost scenario

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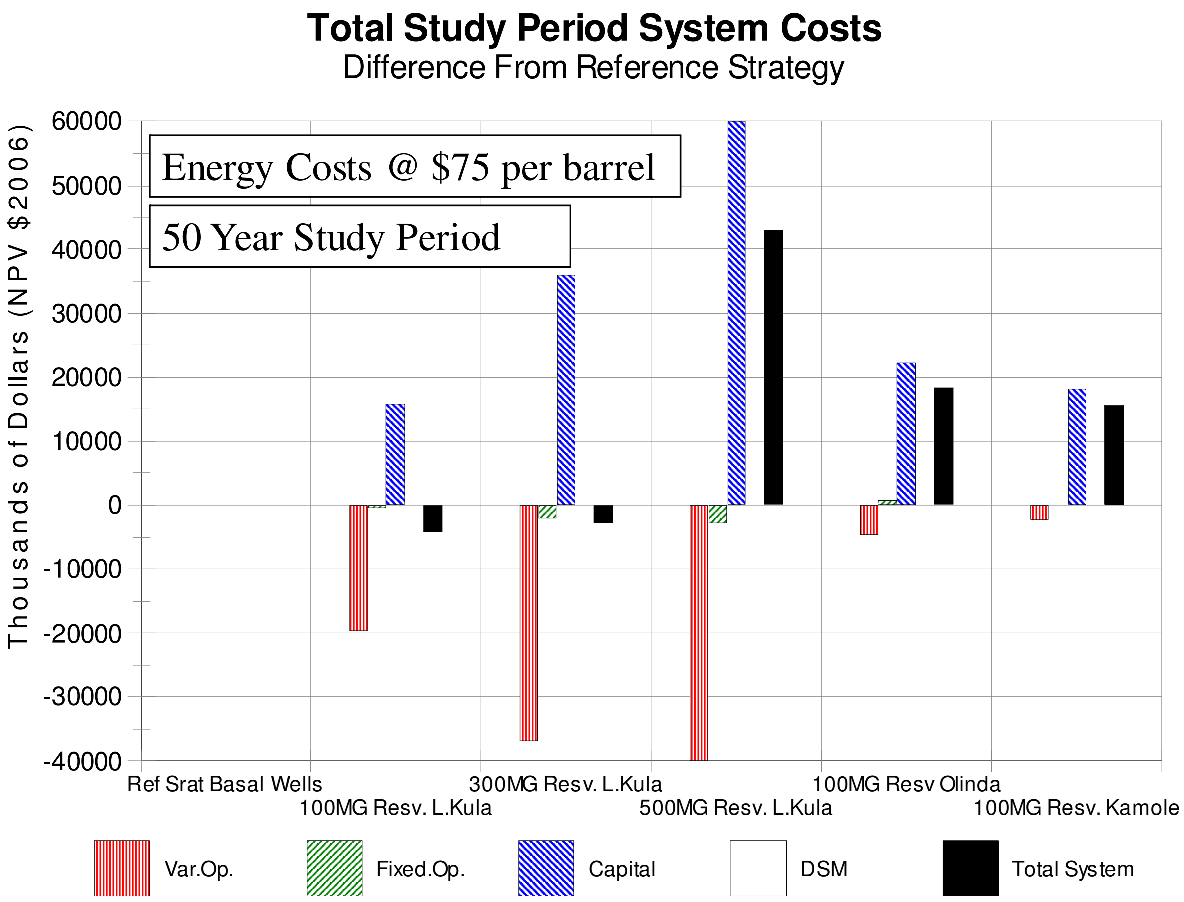
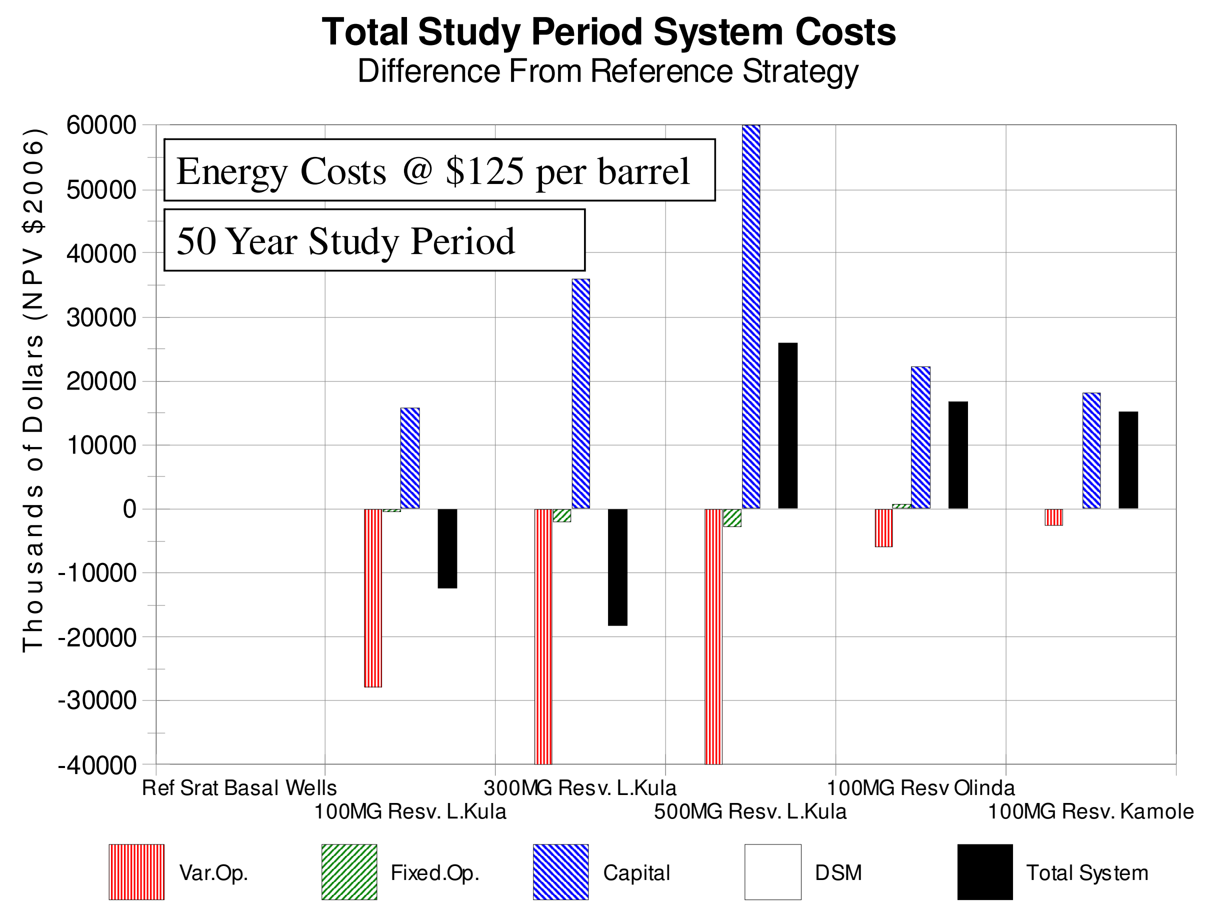


Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same set of strategies as the previous chart except that the costs for a longer 50 year study period are shown.

In the previous chart, considering only the 25 year planning period, none of the reservoir strategies are less expensive than the reference strategy. Because the strategies that incorporate reservoir additions provide substantial benefits (in terms of lower system operating costs) that extend well beyond the 25 year planning period, these strategies appear more cost effective when considered over the longer 50 year study period.

Considered over the 50 year study period, the Lower Kula system is still the most economical location for additional water storage capacity. The optimal reservoir capacity shown here for the Lower Kula system is in the range of 100 to 300 MG. The additional costs of exceeding 300 MG do not produce commensurate benefits.



Alternate Upcountry Reservoir Locations and Capacities

50 Year Planning Period NPV Costs; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies as the previous chart except that higher energy costs are assumed. The electrical costs assumed in the analyses shown on this chart are the “high” energy cost scenario. These costs reflect crude oil prices of $125 per barrel in 2008 ($0.34 per KWH marginal cost in the high power consumption block for large customer MECO Schedule P tariff) assumed to escalate at 1% per year in real terms (1% higher than general inflation).[11]

Considering higher energy costs the 100 MG and 300 MG Lower Kula storage reservoir strategies appear substantially cost effective. Larger reservoir capacity (500 MG) on the Lower Kula system and additional reservoir capacity on the other water systems is not cost effective.

Analysis Including Mitigation of IIFS Wailoa Ditch Base Flow Reduction Impacts

The recent and anticipated further amendments to the IIFS for the East Maui streams will result in decreased base flows in the Koolau/Wailoa ditch system which serves as the water source for the Kamole WTP. With base flows in the ditch system reduced, the reliability of the Kamole WTP

11. The marginal power costs included in the variable costs do not include customer charge and demand charge components of electricity bill. These components of electrical costs are included in fixed operating costs.

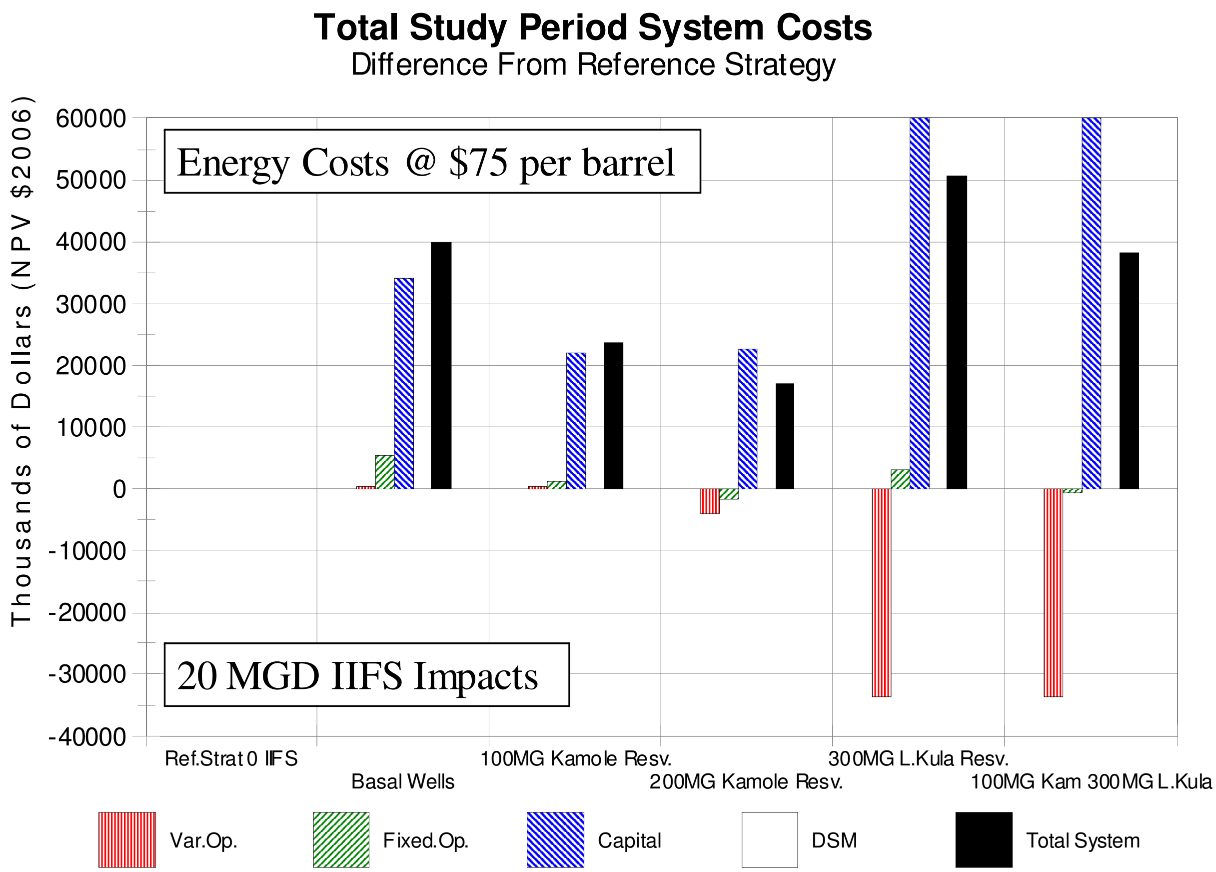
would be reduced which would erode the drought period reliability of the Upcountry District system unless some mitigating actions would be implemented. The reduction in drought period reliability resulting from amendments to the IIFS on East Maui streams could be mitigated by installing additional basal groundwater wells to provide alternate drought period capacity or by installing a raw water storage reservoir to serve the Kamole WTP.

A series of analyses was performed to determine the drought period reliable yield of the Kamole WTP system assuming various sizes of raw water storage reservoirs and considering various levels of reductions in Wailoa Ditch streamflows resulting from IIFS amendments. These analyses are presented in detail in Appendix C to this report and are discussed in the section below presenting the strategy *D. Improving Kamole Water Treatment Plant Capacity.* The analyses show that, in order to maintain the existing 4.5 MGD drought period reliable capacity of the Kamole WTP:

- A reservoir of approximately 100 MG would be required to mitigate the impacts of a 20 MGD reduction in Wailoa Ditch base flows
- A reservoir of approximately 200 MG would be required to mitigate a 30 MGD reduction in base flows.
- A reservoir of approximately 300 MG would be required to mitigate a 50 MGD reduction in base flows.

Based on the results of the mass flow analyses presented in Appendix C a series of economic analyses is presented below that consider various strategies and assumptions to mitigate reductions in Wailoa Ditch base flows.

Note that the economic analyses presented in this section presume that providing raw water storage capacity in order to provide drought period reliable capacity would avoid the need to provide basal groundwater wells for this purpose. If basal wells would be provided by the DWS or acquired from private developers as interim measures prior to commissioning a reservoir, the cost effectiveness of the reservoir strategies would be diminished. See further discussion of the impacts of the timing of resource projects in the later section of this report: “Comparison of Final Candidate Strategies”.



Alternate Upcountry Reservoir Locations and Capacities

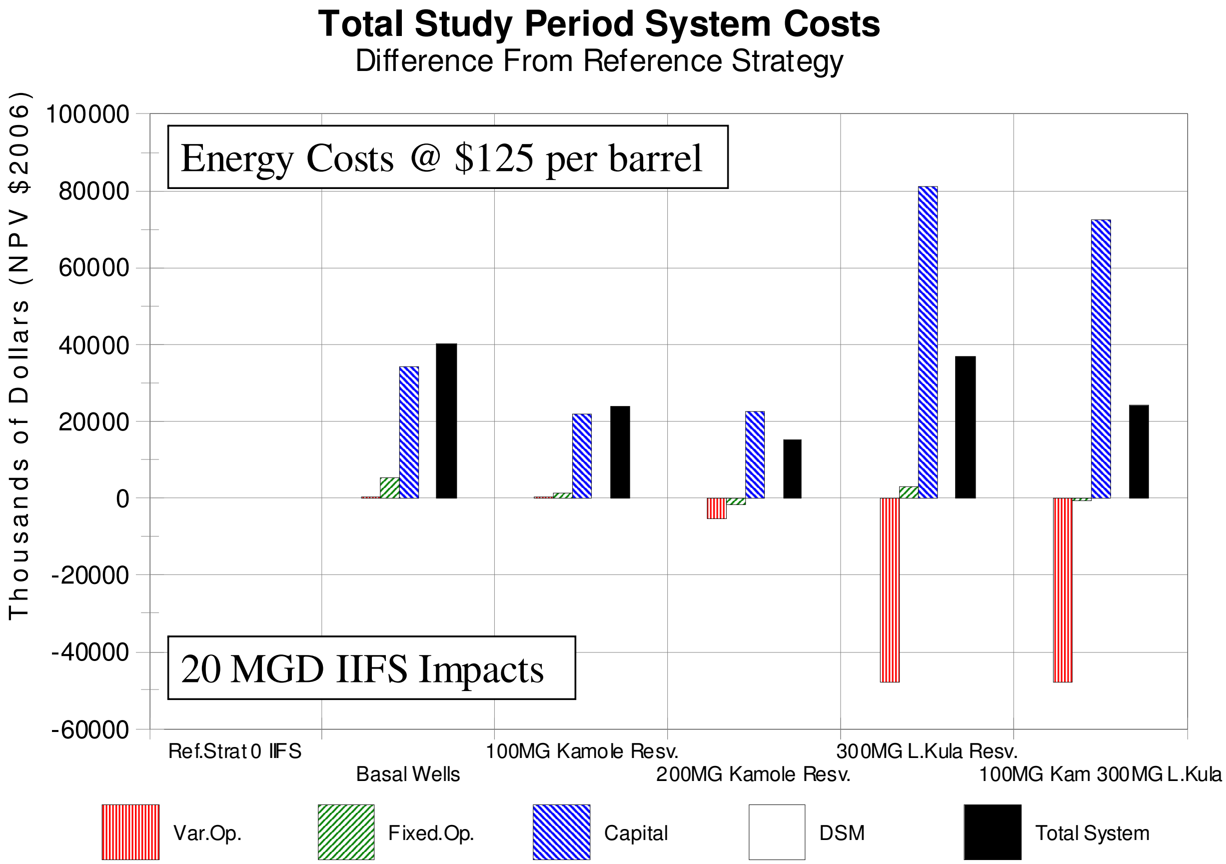
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows a comparison of several strategies including the costs and impacts of measures to mitigate a 20 MGD reduction in Wailoa Ditch base flows that could result from recent and anticipated amendments to the interim instream flow standards for East Maui streams. The "low" energy cost scenario is assumed.

The strategy depicted in the left-most column is the same reference strategy depicted in previous charts showing zero Wailoa Ditch base flow reductions. All of the other strategies depicted include the costs and impacts of mitigating a 20 MGD reduction in Wailoa Ditch base flows. The strategy in the second column from the left is the reference strategy using only additions of basal wells to provide additional needed resources. The remaining columns show strategies that provide additional needed resources using raw water storage reservoirs in several configurations.

The center two columns show strategies incorporating 100 and 200 MG reservoirs at the Kamole WTP respectively. In all other respects the strategies are the same as the reference strategy using basal wells to provide needed capacity. The analysis depicted in these columns shows that raw water storage at the Kamole WTP is more cost effective than providing backup capacity exclusively by addition of basal wells. All of the analyses that include addition of reservoir capacity for the Kamole WTP in this chart and the following charts include the capacity benefits resulting from improvements to the intake structures of the WTP discussed previously in this section of this report.

The strategy depicted in the second column from the right shows that addition of a 300 MG reservoir on the Lower Kula system is not as cost effective as a reservoir at the Kamole WTP as the only raw water storage addition to the Upcountry District systems considering the impacts of lower base flows on the Wailoa Ditch. The strategy in the rightmost column includes a combination of a 100 MG reservoir at the Kamole WTP and a 300 MG reservoir on the Lower Kula system which is more cost effective than the Lower Kula reservoir alone.

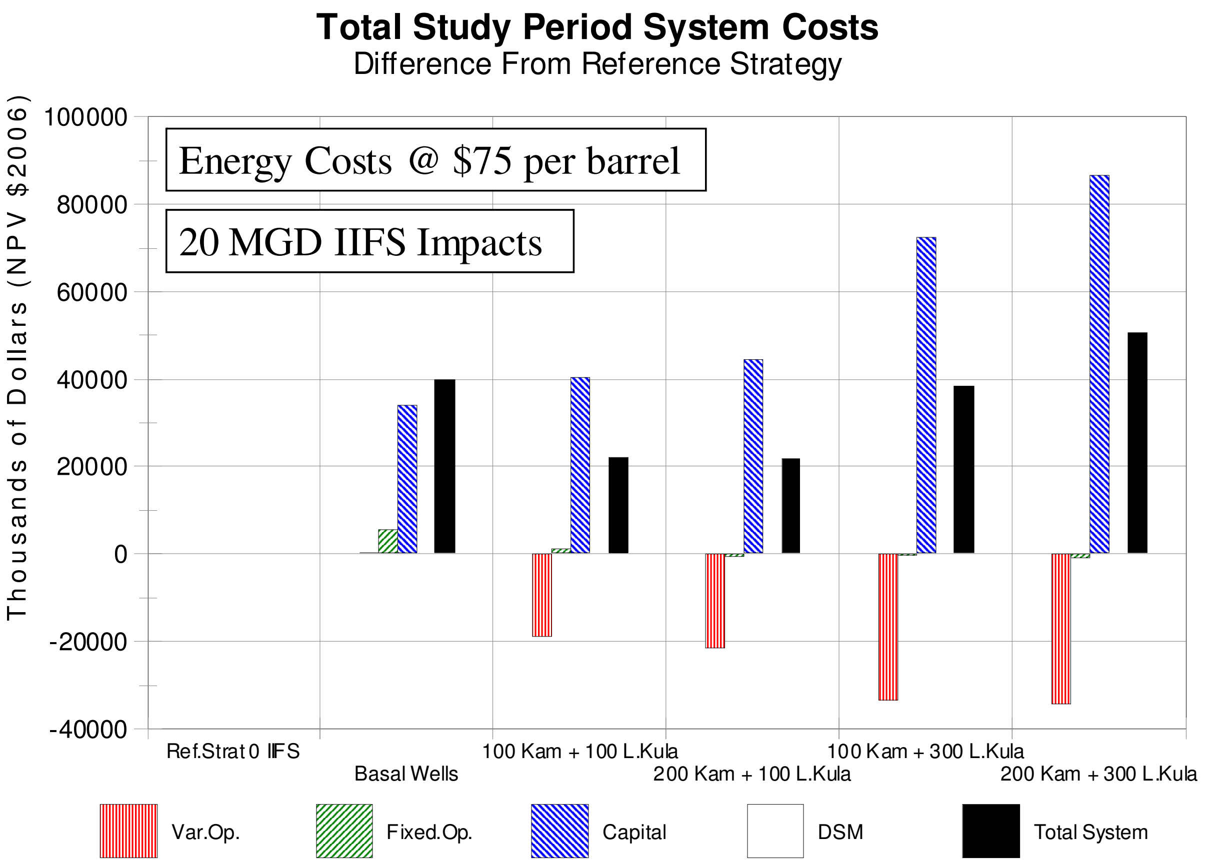


Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies and 20 MGD Wailoa Ditch base flow reduction impacts as the previous chart except that the high energy cost scenario is assumed. With higher energy costs the operational efficiency of the Lower Kula reservoir additions are more prominent.

Note that all of the costs shown in this chart are depicted as differences from the reference basal well development strategy depicted in the left-most column. The costs of all of the strategies are substantially higher assuming the high energy cost scenario. The chart shows the *differences* in costs of the various strategies for the whole Upcountry District systems over the fifty year study period.

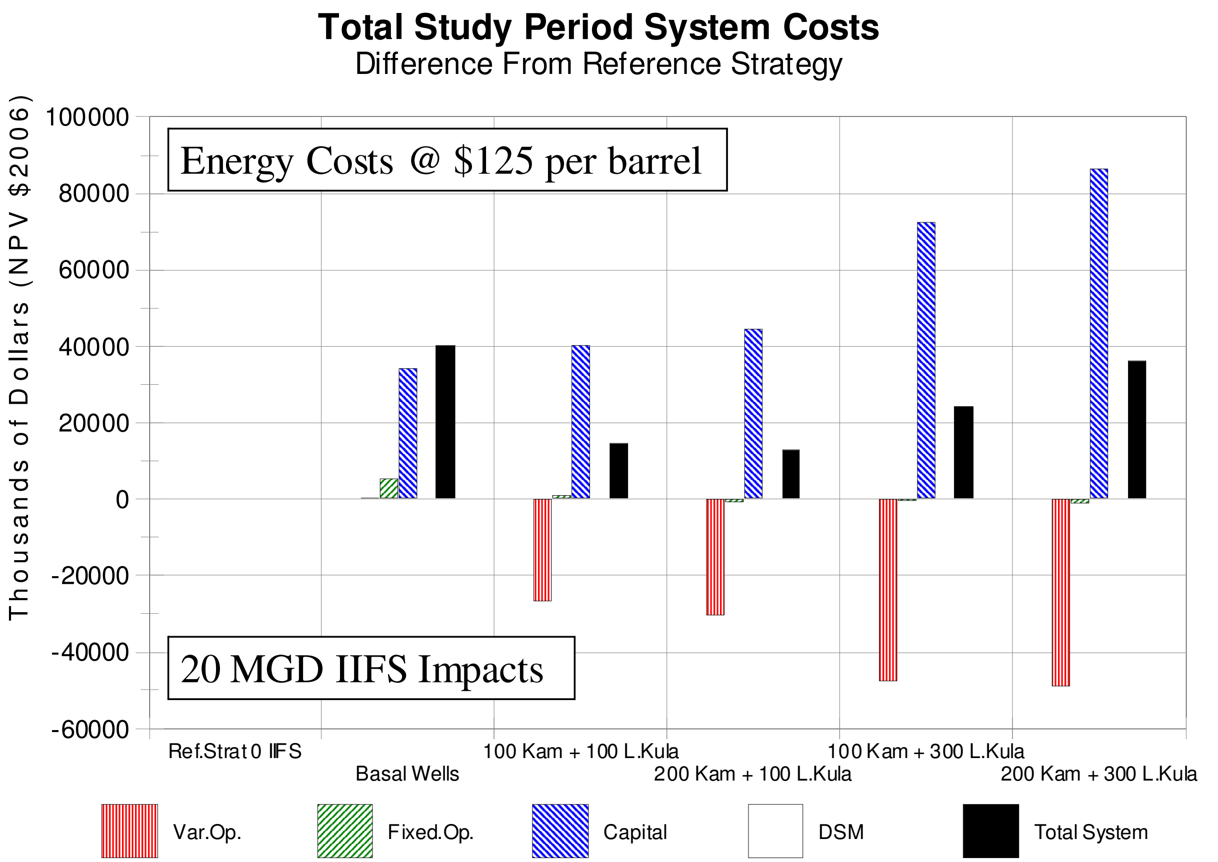
Considering the economics of developing basal wells raw water storage reservoirs, including the need to mitigate anticipated reductions in Wailoa Ditch base flows, strategies that include the addition of reservoir capacity for the Kamole WTP are most cost effective.



Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above and the three following charts below compare strategies incorporating only basal well development with various combinations of 100 and 200 MG reservoirs for the Kamole WTP and 100 and 300 MG reservoirs for the Lower Kula system. The chart above assumes a 20 MGD reduction in Wailoa Ditch base flows and the low energy cost scenario.

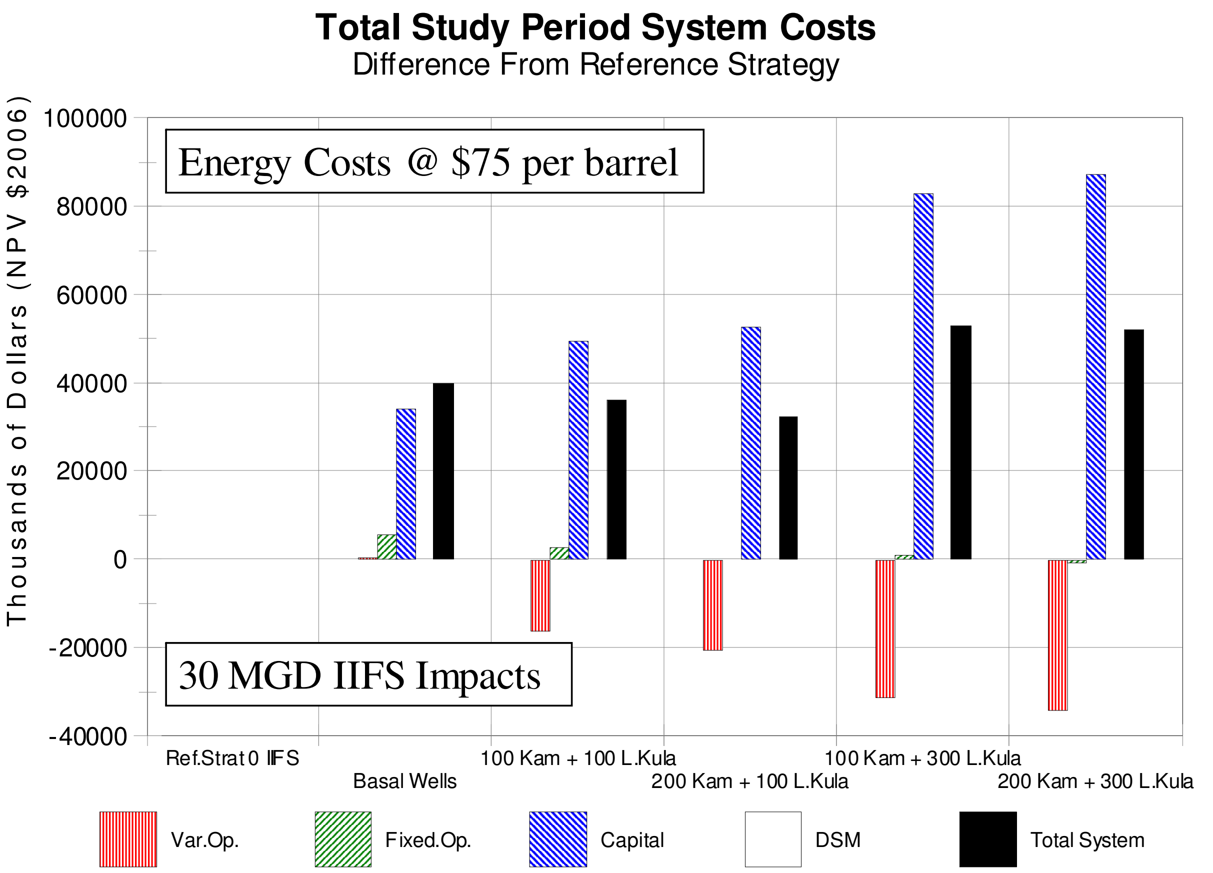
In this scenario the strategies that include a 100 MG reservoir on the Lower Kula system and either a 100 or a 200 MG reservoir for the Kamole WTP are the most cost effective. The strategy that includes a 100 MG reservoir for the Kamole WTP and a 300 MG reservoir on the Lower Kula system is slightly less expensive than the strategy incorporating only basal wells to provide needed resources. The strategy including a 200 MG Kamole reservoir and a 300 MG Lower Kula reservoir is not as cost effective as the other strategies.



Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies and assumptions as the previous chart except that the high energy cost scenario is assumed. In this scenario all of the combinations of raw water storage reservoir additions cost less than the strategy incorporating only basal groundwater wells to meet additional resource needs.

In these strategies the reservoirs at the Kamole WTP serve primarily to provide reliable drought period capacity to the Upcountry District system. The reservoir additions on the Lower Kula system also avoid some costs of providing additional booster pump station capacity and provide substantial additional system operational efficiency benefits (reduced water pumping) in both drought and wetter “normal’ conditions.

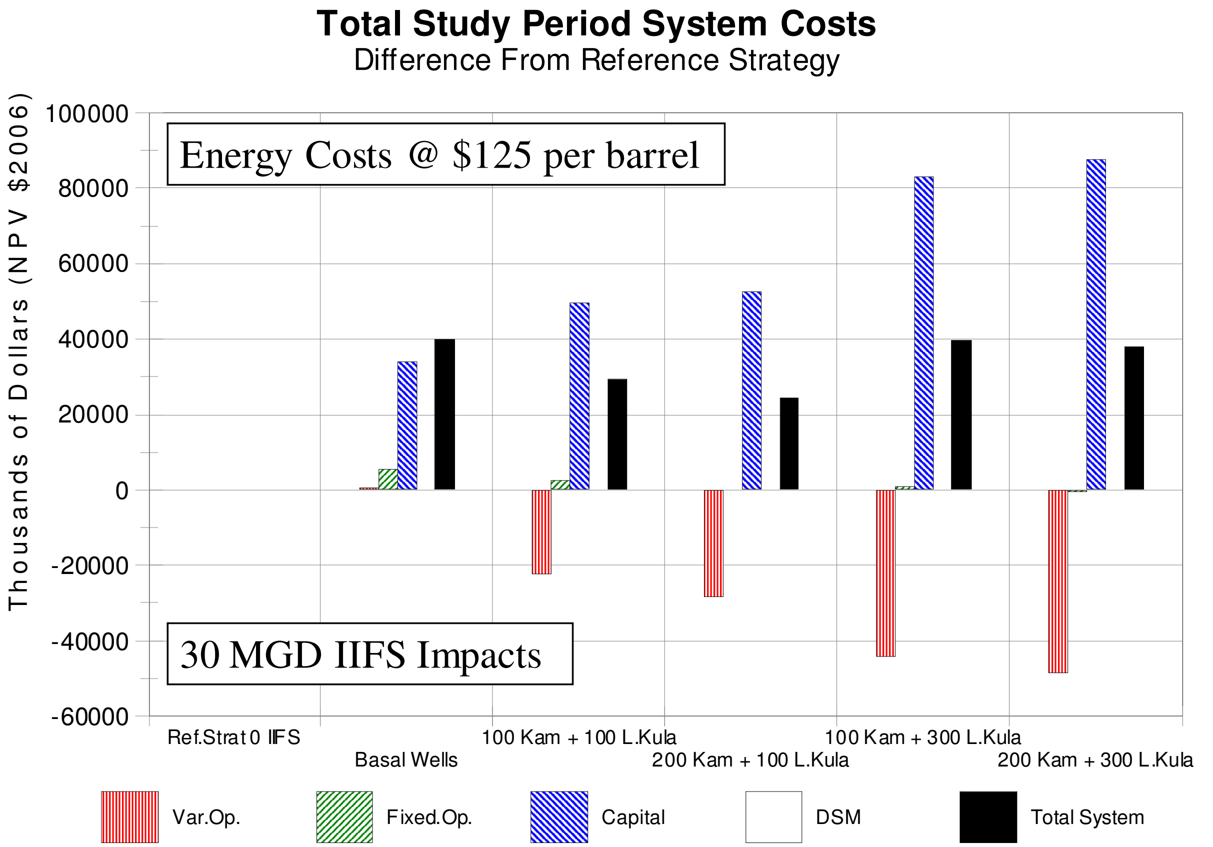


Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 30 MGD Reduction in Wailoa Ditch base flows; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies as the previous chart except that larger 30 MGD reductions in Wailoa Ditch base flows are assumed. The low energy cost scenario is shown.

With the larger reductions in Wailoa Ditch flows the same reservoir additions at the Kamole WTP provide less benefit in terms of drought period reliable capacity. With the lower base flows larger a larger reservoir is needed to provide an equivalent level of reliable capacity. With 50 MGD reductions in Wailoa Ditch base flows it is less expensive to provide reliable capacity using additional basal groundwater wells.[12]

12. This result is shown in the analysis depicted in the following strategy section *D. Improvements to Kamole Water Treatment Plant Capacity*.



Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 30 MGD Reduction in Wailoa Ditch base flows; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same analysis as the previous chart except the high energy cost scenario is assumed. In this scenario all of the combinations of raw water storage reservoirs are equal or more cost effective than the reference strategy which uses only basal wells to meet resource addition needs.

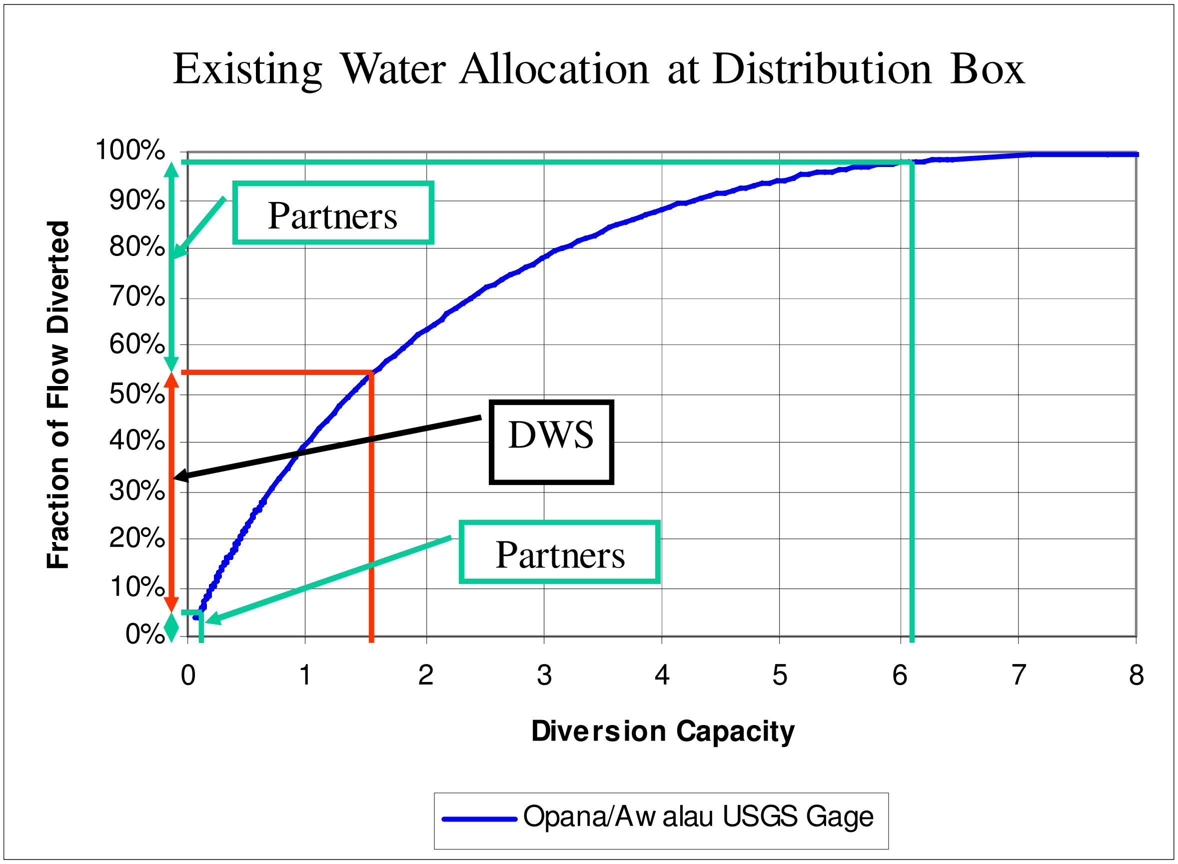
SUMMARY

The analyses above indicate that it would be cost effective to add raw water storage capacity to to both the Lower Kula and Makawao (Kamole WTP) systems.

Additional reservoir capacity on the Lower Kula system provides operational economy by reducing system pumping energy requirements and optimizes drought period service reliability considering the flow characteristics of the tributary streams. The optimal size for new reservoir capacity on the Lower Kula system is in the range of 100 to 300 million gallons. Environmental constraints are an important consideration and may limit the location of a new reservoir on the Lower Kula system to areas near the existing Piiholo Water Treatment plant which could limit the size of viable new storage capacity to approximately 100 million gallons.

Additional reservoir capacity on the Makawao system serving the Kamole WTP would mitigate reductions in source water base flows resulting from existing and anticipated amendments to the instream flow standards on tributary East Maui streams. The optimal size for new capacity on the Makawao system is in the range of 100 to 200 million gallons depending on the ultimate magnitude of base flow reductions.[13]

Determination of the optimal size of reservoirs on both systems will depend on more resolute determination of several factors, principally including: determination of IIFS impacts on Wailoa Ditch base flows, reservoir siting constraints and reservoir construction costs.



Opana / Awalau Source Existing Water Allocation

Opana / Awalau Source Analysis

A diversion in the Opana stream routes water through a tunnel to the Awalau stream area. A collector box distributes water from the tunnel and an Awalau spring to pipes serving several users including the DWS. The chart above shows the streamflow characteristics of water emerging from the Opana/Awalau tunnel and the current allocations of water to the DWS and the agricultural partners.

Prior to the Clean Water Act water treatment requirements, this source supplied water to the Maluhia tank on the DWS potable water system. Currently, the majority of the water from this

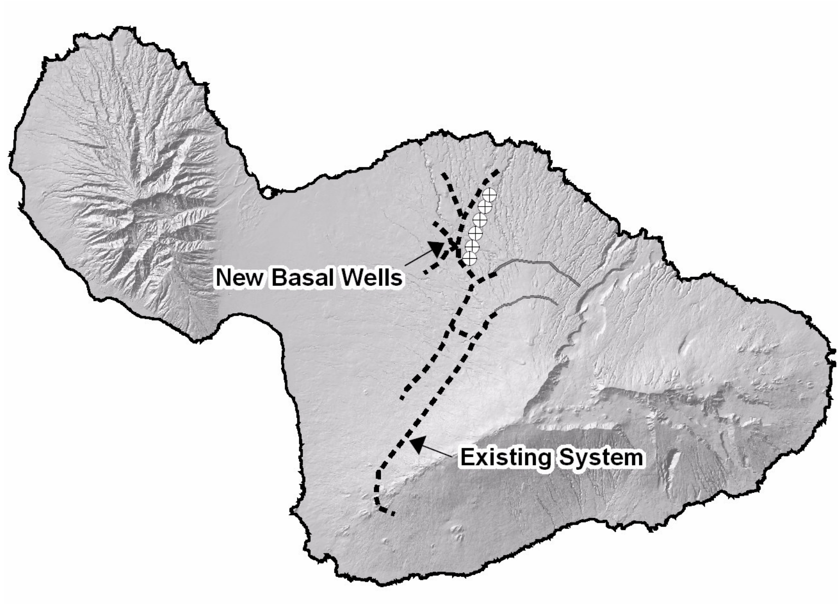
13. Note that the economic analyses presented in this section presume that providing raw water storage capacity in order to provide drought period reliable capacity would avoid the need to provide basal groundwater wells for this purpose. If basal wells would be provided by the DWS or acquired from private developers as interim measures prior to commissioning a reservoir, the cost effectiveness of the reservoir strategies would be diminished. See further discussion of the impacts of the timing of resource projects in the later section of this report: “Comparison of Final Candidate Strategies”.

source feeds a 10 million gallon reservoir serving and managed by a partnership of agricultural users. A minor portion of non-potable water is provided to existing DWS customers. All of the current use is for non-potable agricultural uses.

The Opana/Awalau water source was evaluated as a potential resource option as a more reliable source for agricultural uses or for treatment to supplement DWS potable uses. A mass flow analysis determined the reliable yield of this source assuming several possible reservoir capacities. Because there are extended periods the analysis was based on providing "semi-reliable yield" in which the reservoir would be empty 10% of the time. As an integral system only small gains in semi-reliable yield would result from additional reservoir capacity. For example, doubling the current 10 MG reservoir capacity would increase the semi-reliable yield of the Opana/Awalau system by 22%. Based on this analysis it was concluded that it is not practical to provide drought period service reliability to the Upcountry District system by adding reservoir capacity for this resource.

Options for this resource include maintaining the current use as a non-potable agricultural water source or installing a small water treatment unit at the Maluhia tank site. The economics of installing water treatment depends upon the DWS system status and operation. It would be economical to displace water otherwise produced by basal sources or the Kamole WTP, but water from the Opana source would rarely be available in the dry conditions that exist when these more expensive resources are required. Usually when water is available from the Opana source water is also available from the Piiholo WTP for this area. It is not currently economic to displace water produced at the Piiholo WTP with a new treatment unit at the Maluhia tank site.

Based on this analysis it was concluded that it is not economical to build a water treatment unit for this source to serve potable needs at this time. This source does have value to serve potable uses in the future when more water this area is served by sources from basal wells or water pumped from lower elevations.



C. "Drought-Proof" Full Basal Well Backup

Summary

At the request of the Upcountry Water Advisory Committee one final candidate strategy provides for "drought-proof" water service reliability. This strategy provides sufficient new basal groundwater well development to provide sufficient water to meet projected Upcountry District water demand assuming limited or no availability of water from surface water sources.

Development of sufficient new basal groundwater wells to provide for the full needs of the Upcountry District system is expensive both in terms of necessary capital costs and long term operating costs. Since the number of new wells in this strategy would be determined by extreme drought conditions which would seldom actually occur, most of the capacity of the wells would seldom be used

Project Design Alternatives

This strategy uses multiple basal wells and associated necessary booster pump additions to provide sufficient water for the Upcountry District system without any water use restrictions and without relying on surface water systems that are subject to drought period limitations. Two principle design alternatives were examined. In the most extreme case sufficient basal wells were provided to backup the entire system assuming no output from any surface water sources in worst case drought conditions. In a second alternative it was assumed that there would be no available water from the Upper Kula and Lower Kula surface water sources but a limited amount of water production capacity (4.5 MGD) would remain available from the Kamole WTP taking water from the Wailoa Ditch.

The economic analysis of this strategy assumes that sufficient basal wells are installed to provide extreme drought period production service reliability. The analyses do not, however, assume that most or all of the water for the Upcountry system would be produced by extensive basal groundwater pumping. The operation costs of this strategy would actually be very similar to those in the Incremental Basal Well Development strategy (reference strategy).[14] As in all of the economic analyses of the final candidate strategies, in both normal and drought periods the available water source resources would be operated in the most economical manner. Most of the basal wells added in this strategy to provide full drought reliability would be operated very seldom.

Policy and Feasibility Considerations

Cost versus Reliability

The characterization and analysis of this strategy is primarily a determination of the cost of providing full "drought-proof" water service reliability for the Upcountry District system. From a technical standpoint it would be feasible to provide enough basal wells and booster pumps to supply the needs of the Upcountry District system. From an economic standpoint the high capital costs of this strategy beg careful consideration of the value of providing full drought-proof service reliability.

General Basal Well Development Issues

The issues discussed in the section above regarding the Incremental Basal Well Development strategy would also apply to development of more extensive basal wells in this strategy. These concerns include compliance with the EMPLAN consent decree and issues associated with non-DWS development of wells. See the discussion of these issues in the Incremental Basal Well Development sections above.

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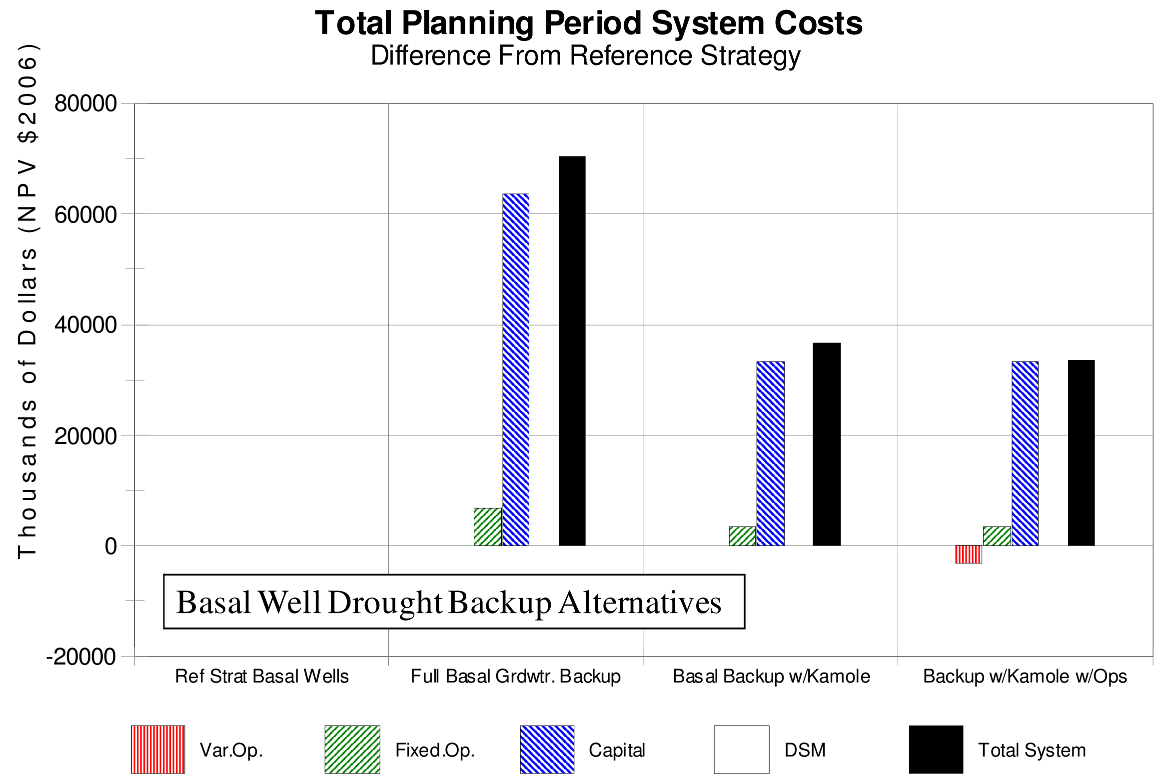
14. Note that the Incremental Basal Well Development strategy (reference strategy) provides sufficient new wells to meet the planning reliability criteria for the Upcountry District. The reference strategy provides substantially more service reliability than the existing system and is sufficient to meet the economic analysis modeling requirements. The reference strategy includes enough new well capacity to meet reliability criteria that much of the additional well capacity will not often be used. It is, nevertheless, not "drought-proof".



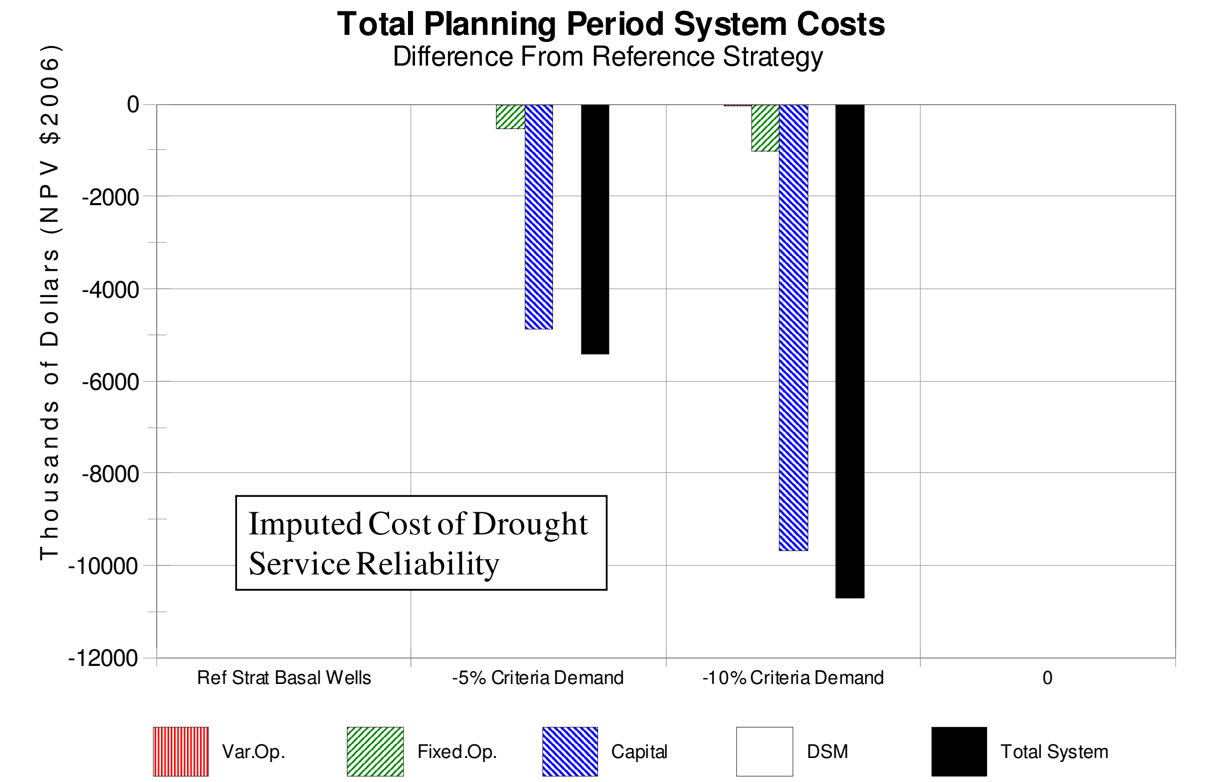
Basal Well Drought Backup Alternatives
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Economic Analysis

The chart above shows three scenarios that were analyzed and compared to the reference strategy. This analysis shows total system costs for the 25 year planning period assuming the low energy price scenario.

The "Full Basal Groundwater Backup" strategy in the chart above assumes that sufficient new basal wells would be developed to provide reliable service without relying on any surface water sources in extreme drought conditions. The "Basal Backup w/Kamole" strategy is the same except that 4.5 MGD production capacity is assumed to be available from the Kamole WTP in extreme drought conditions. The "Backup w/Kamole w/Ops" strategy is the same as the "Basal Backup w/Kamole" strategy except that the Upper and Lower Kula system reservoirs are allowed to operate with additional drawdown than otherwise assumed in recognition of the existence of the extensive backup well and booster capacity added to the systems. Neither of the analyses that presume 4.5 MGD drought period production capacity from the Kamole WTP explicitly include consideration of anticipated reductions in the base flows of the Wailoa Ditch resulting from implementation of IIFS on East Maui streams.

Providing extensive backup resources to provide additional water service reliability for the Upcountry District system would cost (in addition to the reference strategy costs) about $70 million (NPV) to provide reliable drought period service without surface water sources and about $30 million (NPV) assuming partial surface water source availability.



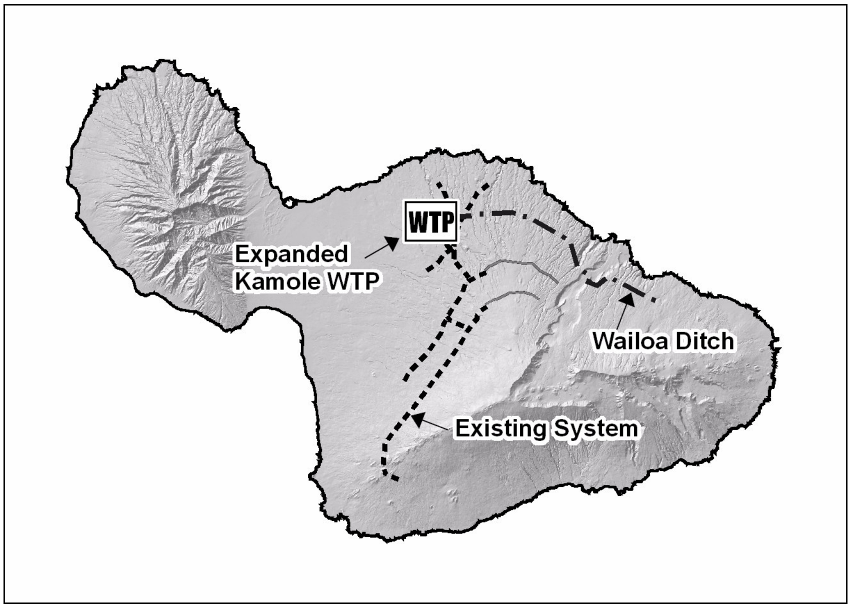
Imputed Cost of Drought Service Reliability
25 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Because the principal differences in the economics of these strategies are the capital costs and some fixed operating costs associated with construction of basal wells that are seldom operated, the results of the analysis are very similar in the 50 year study period analyses and in analyses that assume higher energy costs.

The chart above shows an alternate analysis of the cost of providing reliable service on the Upcountry District systems. The previous chart examined the costs to increase service reliability beyond the planning reliability criteria used in the analyses of the other strategies in this report. The chart above examines the costs of providing less reliability than what is specified in the planning reliability criteria.

Two scenarios are examined that assume that the system design and reliability criteria used in determining the timing and need for source resources are relaxed by five percent and ten percent of criteria demand respectively. The criteria used in the modeling analyses are described in a section above titled “System Design and Reliability Criteria”. These criteria specify that the drought period capacities must be sufficient to meet 1.5 times drought period demand with source constrained consistent with drought period conditions. The two scenarios above would reduce the standards applied to require meeting 1.45 and 1.4 times drought period demand respectively. Both of these scenarios would provide standards that would provide service that is more reliable than the existing system.

A basic conclusion of this analysis is that reliability comes at a high cost. One recommendation of this report (in the Recommended Upcountry District Plan) is to commission a methodical study to establish clear and meaningful reliability criteria to determine the availability of water and the extent of the need for new system resources on the Upcountry system. The type of analysis depicted in the chart above can inform the determination of optimal criteria to balance system reliability and cost.



D. Improved Kamole Water Treatment Plant Capacity

Summary

This strategy features improvements to the existing Kamole Water Treatment Plant (WTP) to provide additional water volume and/or drought period reliable capacity and to mitigate impacts of anticipated reductions in Wailoa Ditch base flows resulting from amendments to the interim instream flow standards on East Maui streams. Options considered include expansion of WTP installed filter capacity, improvements to the WTP water intake structure, and addition of a raw water storage reservoir.

The Kamole WTP is in the process of being upgraded by retrofitting the existing modules with higher capacity filters. Further expansion of the overall capacity of the WTP would not substantially increase the drought period capacity provided by the WTP since this is constrained by limited drought period source water availability.

As explained below, expansion of the Kamole WTP in conjunction with transmission connection to serve the Central District system is not a practical option.

One important potential improvement to the Kamole WTP would be installation of a raw water storage reservoir to mitigate anticipate reductions in Wailoa Ditch base flows. In order to mitigate reductions the base flows of the source of water to the Kamole WTP it would be necessary either to (1) install additional backup basal groundwater well capacity or (2) provide additional raw water reservoir storage to serve the Kamole WTP. In order to maintain the 4.5 MGD Kamole WTP drought period reliable capacity by providing raw water storage a 100 MG reservoir would be necessary to mitigate a 20 MGD reduction in Wailoa Ditch base flows. A 200 MG reservoir would be necessary to mitigate a 30 MGD base flow reduction.

Improvements to the intake structures of the WTP could increase drought period plant capacity which is currently a limiting factor when flow is low in the Wailoa Ditch. This would provide value to the system by reducing the amount of otherwise necessary groundwater backup well development and could serve as a contingency measure pending installation of raw water storage or additional basal groundwater well capacity. Installation of a raw water storage reservoir would incorporate these improvements by providing ample source water to the WTP during low ditch flow conditions.

Project Design Scenarios

Improvements to Increase Drought Period Reliable Yield

Prior to completion of a raw water storage reservoir (or if a raw water reservoir is not constructed) modifications could be made to the existing WTP intake structures in the Wailoa Ditch to expand the amount of water that can be withdrawn from the ditch in low flow conditions. Currently the WTP capacity is limited by intake constraints when ditch flows are low. Specific project designs were not considered explicitly but are presumed to be feasible. Depending on the design and operation of the source intake from the Wailoa Ditch, this strategy could include negotiated agreement revising the existing Memorandum of Understanding that allocates water between EMI and DWS when Wailoa Ditch flows are low.

Installation of a Raw Water Storage Reservoir to Serve the Kamole WTP

This strategy would include addition of a raw water storage reservoir to mitigate reductions in Wailoa Ditch base flow resulting from recent and further anticipated amendments to the interim instream flow standards for East Maui streams. Several reservoir sites and reservoir configurations have been examined in previous studies for the DWS. Several reservoir sizes and configurations were analyzed as discussed in the economic analysis below.

Interconnection with the Central District System

Expansion and interconnection of the Kamole Water Treatment Plant with the Central District system could provide a limited amount of additional redundancy of production equipment for the Central system and the Upcountry system (with the addition of sufficient additional booster pumps). The amount of this contribution is limited, however, because there would be some extended periods of time when all available source water to the Kamole WTP would be needed for existing source needs for the Upcountry system. This constraint is expected to become more acute with anticipated reductions in Wailoa Ditch base flow.

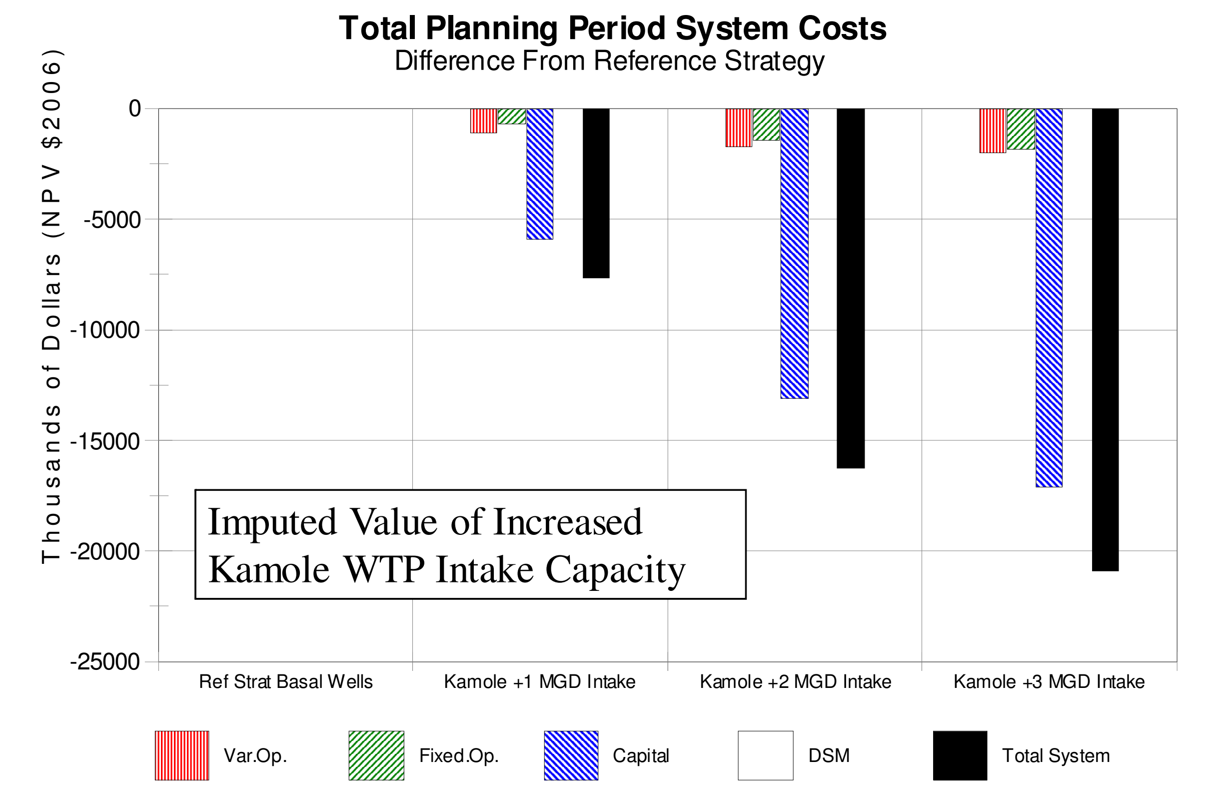
Some economic benefit would also result from interconnection during times that ample water is available in the Wailoa ditch (supplying the Kamole WTP) that could serve the Central system and displace more expensive Central system resources. The costs of expanding the Kamole WTP, however, exceed these system operation efficiency benefits (even without considering the costs of necessary interconnecting transmission improvements).

Because the amount of water available to the DWS is ultimately limited by the flows in the Wailoa ditch and this capacity is currently relied upon to meet existing and future needs of the Upcountry system, this option would not, by itself, provide any substantial additional new water sources that would effectively meet new water demands on either system. See the related discussion on system interconnection in the previous section "Interconnection with the Central System" in the section addressing the Incremental Basal Development Strategy.

Policy and Feasibility Considerations

Continued / Expanded Use of Diverted Stream Water

This strategy would continue and potentially expand the use of water diverted from streams. This must be considered regarding the WUDP planning objectives to promote stream restoration, support cultural resources and provide sufficient water for agricultural uses. To the extent that water currently diverted from East Maui streams may be returned to the streams by amended instream flow standards established by the CWRM, mitigating measures must be taken or the long-term availability of diverted water for municipal uses may be abridged. Diversion of surface water also affects discharge of fresh water to the ocean, which may affect fishing resources and the marine environment.



Imputed Value of Increased Kamole WTP Drought Period Intake Capacity
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Agricultural versus Municipal Use of Drought Period Surface Water

By taking additional water from the Wailoa Ditch for municipal uses, this strategy could reduce the amount of water available in the Wailoa/Hamakua Ditch available for agricultural purposes. This could be mitigated by arrangements to pump water from the DWS Hamakuapoko wells to the Hamakua Ditch (just below Kamole Wier) to replace incremental water withdrawals from the Wailoa Ditch.

Economic Analysis

The economic analysis of this strategy includes two approaches. The first approach focuses on determining the value to the Upcountry District water system of increasing the drought period reliable capacity of the Kamole WTP by improvements to the WTP intake structure. The second approach examines the costs and impacts of mitigating reductions in Wailoa Ditch base flows by installation of basal groundwater wells or providing raw water storage reservoir capacity.

The extent to which drought period reliability could be improved by changes to the Kamole WTP intake structures has not been accurately determined. Three scenarios were analyzed assuming that the drought period reliable capacity could be increased by 1 MGD, 2 MGD and 3 MGD respectively. This range of potential improvements is based on the fact that the drought period reliability determined by analysis of the historical Wailoa Ditch flows is about three MGD higher than recent actual WTP operation experience.

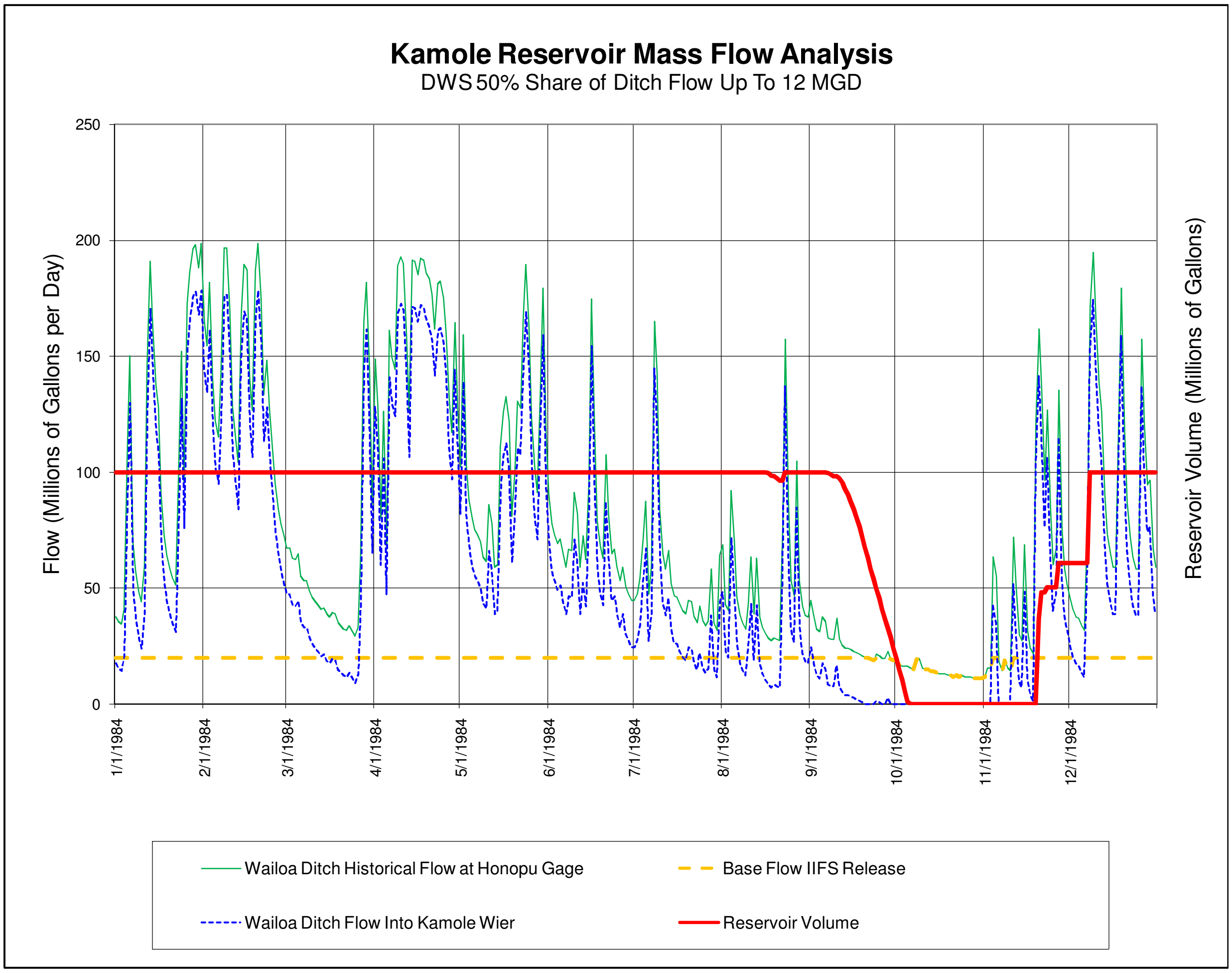
The chart above shows 25 year planning period total Upcountry District system costs for the reference strategy and three scenarios with increased Kamole WTP drought period reliable capacity resulting from improvements to the WTP intake structures. The benefits provided by improvements to the intake structures shown in the chart above include (1) decreased capital and fixed costs from deferral of basal wells that would otherwise need to be installed to provide drought period reliability and (2) some variable operation costs resulting from decreased system pumping requirements.

If the drought period reliable capacity of the Kamole WTP were increased by 1 MGD the benefit to the Upcountry District System would be about $8 million (NPV) over the 25 year planning period. If costs to make the improvements are less than this amount they would be cost effective. Further improvements would provide more value to the system with some diminishing returns. Ultimately, the magnitude of feasible improvements is limited by the drought period flow of the Wailoa Ditch.and contractual arrangements with EMI.

Analysis of IIFS Impacts on the Kamole WTP

The recent and anticipated amendments to the IIFS for the East Maui streams will result in decreased base flows in the Koolau/Wailoa ditch system. With base flows in the ditch system reduced, the reliability of the ditch system as a source of drought period reliable capacity is diminished. One method to mitigate this erosion of drought period reliable capacity is to provide raw water storage reservoir capacity to provide a reliable system yield in drought periods.

A series of analyses was performed to determine the drought period reliable yield of the Kamole WTP system assuming various sizes of raw water storage reservoirs and considering alternate assumptions regarding the allotment of Wailoa Ditch water to the WTP, the assumed storage reservoir and to A&B for irrigation. A mass flow model was developed which examines daily ditch flows for a 23,680 day period of record from 1923 to 1987. The model determines the impacts of reductions in Wailoa Ditch base flow on the drought period reliability of the Kamole WTP and determines the effectiveness of various sizes and configurations of reservoirs and water allotment protocols to mitigate the impacts of reductions in base flow.

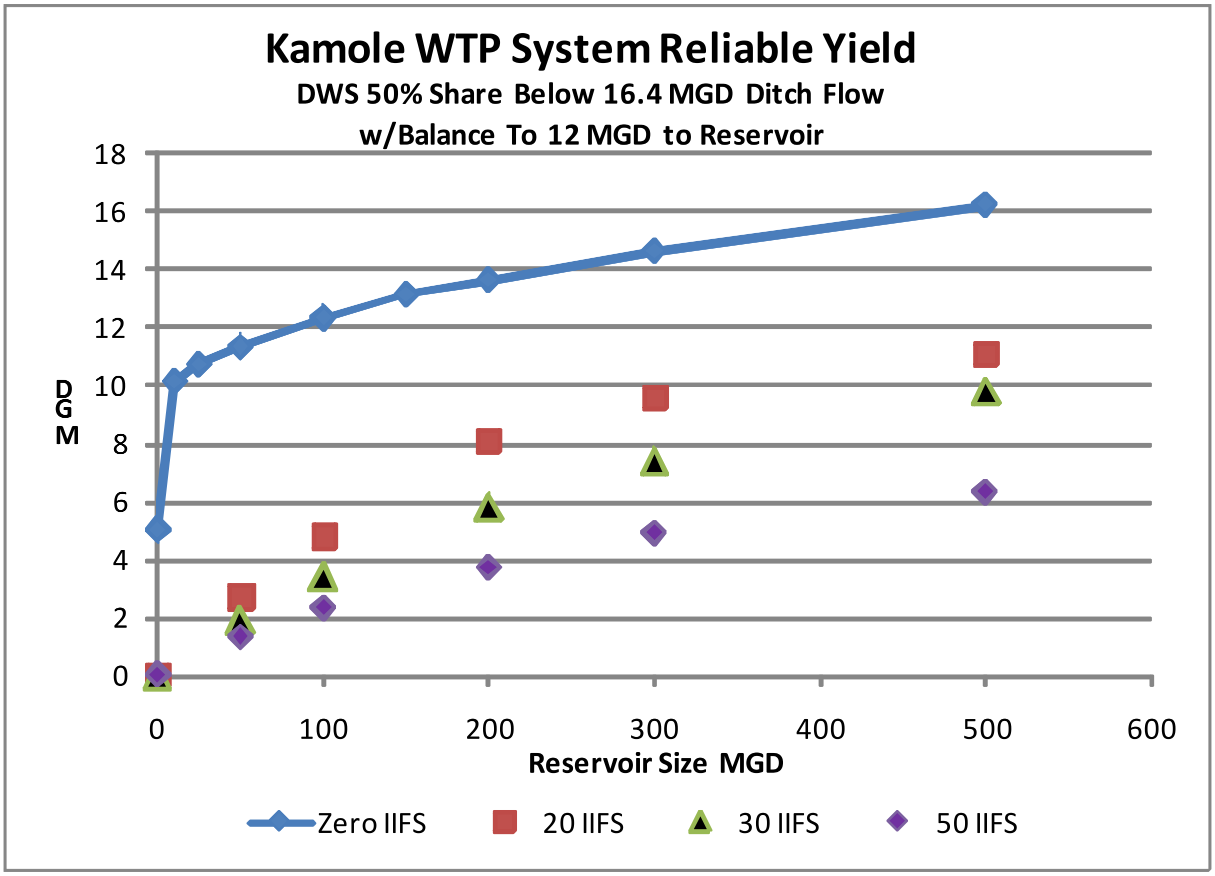


Analysis Assumptions	MGD
Base Flow IIFS Release Impact	20.00
Wailoa Ditch Losses (Honopou to Kamole)	0.00
DWS Base Diversion To WTP	4.60
HC&S Base Agricultural Use	100.00
Reservoir Capacity (MG)	100.00
DWS Resv. Yield to WTP (Above Base)	0.00
Total DWS Target Use (Base + Yield)	**4.60**

Deficiency Statistics	With No Reservoir DWS Base Diversion Deficient	With Reservoir DWS Base + Yield Deficient
Period of Record 1922 - 1987		
Total Days In 23,680 Day Record	822.00	117.00
Percentage Days Deficient	3.47%	0.49%
Consequtive Days Deficient	54.00	29.00

Wailoa Ditch Flows Showing 20 MGD Reduction in Base Flow, CY1984, With Water Deficiency Statistics For Kamole WTP At 4.6 MGD Drought Period Withdrawal Assuming DWS 50% Allotment of Water At Low Flow Conditions Up to 12 MGD Flow With 100 MG Reservoir Capacity With No Contribution To Reservoir Unless Ditch Flows Exceed DWS Draw Plus 100 MGD HC&S Use.

The chart above shows a one year segment of a mass flow analysis assuming a 20 MGD reduction in Wailoa Ditch base flow and a 100 MG reservoir at the Kamole WTP site. Appendix C of this report includes a description of the mass flow analysis and a series of similar charts under various flow reduction and water allocation scenarios. Based on a series of similar mass flow analyses the effectiveness of various sizes of reservoirs to mitigate various levels of base flow reductions was determined. The results of one set of analyses is depicted in the chart below.

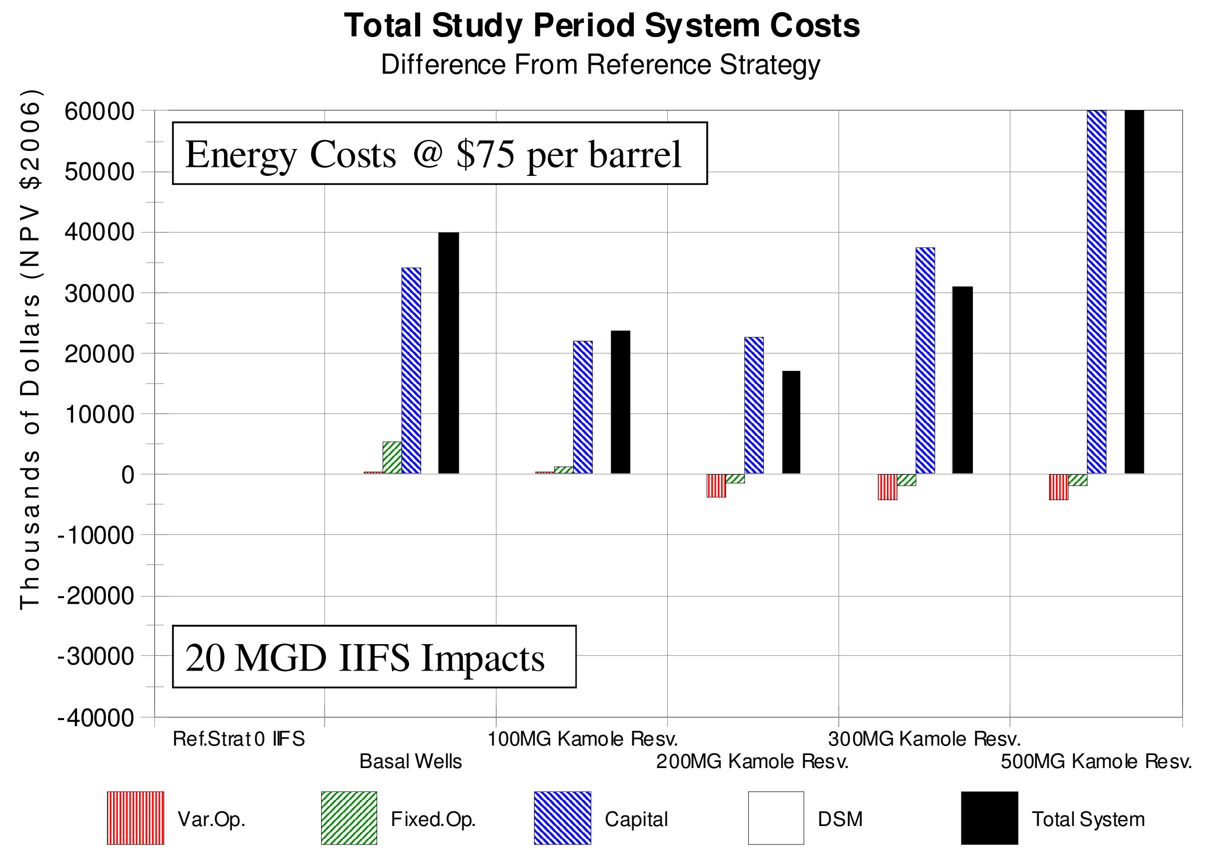


Drought period reliable capacity of the Kamole Water Treatment Plant for various raw water storage reservoir capacities for a range of reductions (0, 20, 30 and 50 MGD) in Wailoa Ditch base flows resulting from amendments to the interim instream flow standards for contributing East Maui streams.

The chart above shows the drought period reliable capacity of the Kamole WTP under various levels of reductions in Wailoa Ditch base flow for several sizes of raw water storage reservoirs.

Note that in the scenario with zero reduction of Wailoa Ditch base flows, the installation of even the smallest size reservoir increases the reliable yield of the Kamole WTP substantially. This is because it is presumed that, with the installation of any reservoir, the existing constraints associated with the existing WTP intake structure would be mitigated and the reliable yield would increase to the limits that are due to solely to ditch flows and contractual allotments.

This analysis shows that, in order to maintain the existing 4.5 MGD drought period reliable capacity of the Kamole WTP, a reservoir of approximately 100 MG would be required to mitigate the impacts of a 20 MGD reduction in Wailoa Ditch base flows and a reservoir of approximately 200 MG reservoir would required to mitigate a 30 MGD reduction in base flows. A reduction of 50 MGD would require a reservoir of approximately 300 MG. (See Appendix C for a more detailed discussion.)



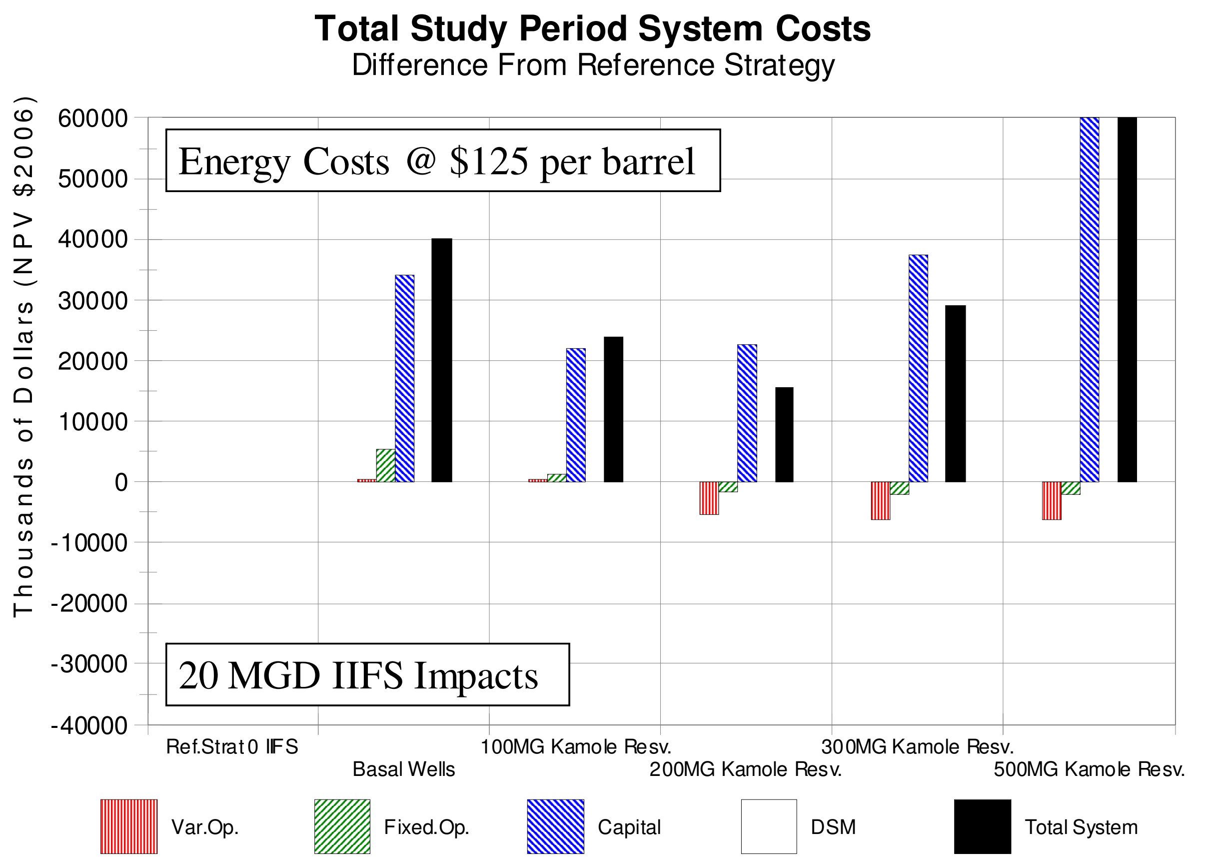
Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Economic Analysis Including Assessment of IIFS Impact Mitigation

A series of economic analyses was performed to determine the study period costs of various combinations of possible reservoir sizes and locations on the Upcountry District system under several energy cost and IIFS impact scenarios. Several of these analyses are presented in the chart above and several charts below.

Each chart shows the 50 year study period costs for the Upcountry District system. The left-most column of each chart shows the reference strategy (providing all needed new capacity with basal groundwater wells) assuming zero IIFS impacts on Wailoa Ditch base flows. All of the other columns show costs assuming the indicated level of Wailoa Ditch base flow reductions resulting from implementation of amended IIFS. The four columns on the right show system costs assuming installation of 100, 200, 300 and 500 million gallon reservoirs to serve the Kamole WTP.

The chart above shows analyses assuming 20 MGD IIFS Wailoa Ditch base flow reductions and the low energy cost scenario. Installation of a 100 MG reservoir would approximately maintain the existing drought period reliability of the Kamole WTP assuming a 20 MGD reduction in source base flows. The larger reservoirs would provide add it on al drought period reliability, reducing the capital and fixed costs of basal groundwater wells that would otherwise have to be installed to maintain drought period reliability. Under this set of assumptions it would be more

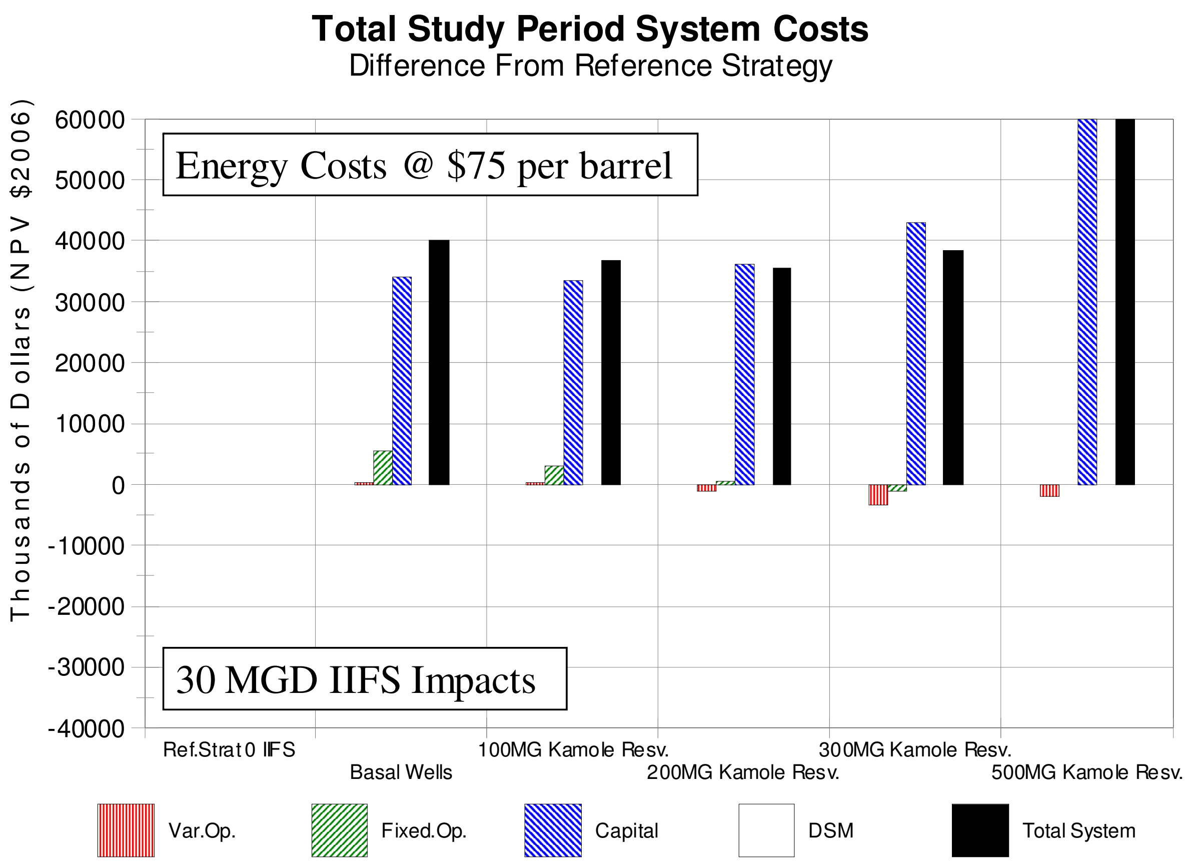


Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 20 MGD Reduction in Wailoa Ditch base flows; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

cost effective to install up to 300 MG of reservoir capacity than it would be to install only basal wells.

The chart above shows the same strategies and assumptions as the previous chart except that the high energy cost scenario is assumed. Note that this chart shows only **differences** between the various strategies. The costs of all of these strategies is substantially higher than the costs in analyses shown on the previous chart which assumes lower energy costs. The differences in costs between the various strategies changes very little with changes in energy costs. This is because there is very little difference in the amounts of water pumped in these strategies. The primary difference in these strategies is the means by which drought period reliability is maintained. In the basal well strategies (the reference strategies) drought period reliability is maintained by a number of basal wells that are available for drought period service but are actually used very little. In the strategies that include additional raw water storage, drought period reliability is maintained to increasing degrees (with increasing reservoir volumes) by maintaining reservoirs that are primarily kept full almost all of the time to maintain reliable capacity.

Unlike the Lower Kula reservoir options, the reservoir options at the Kamole WTP are most economically operated to maintain reliable capacity rather than to increase economical water production.

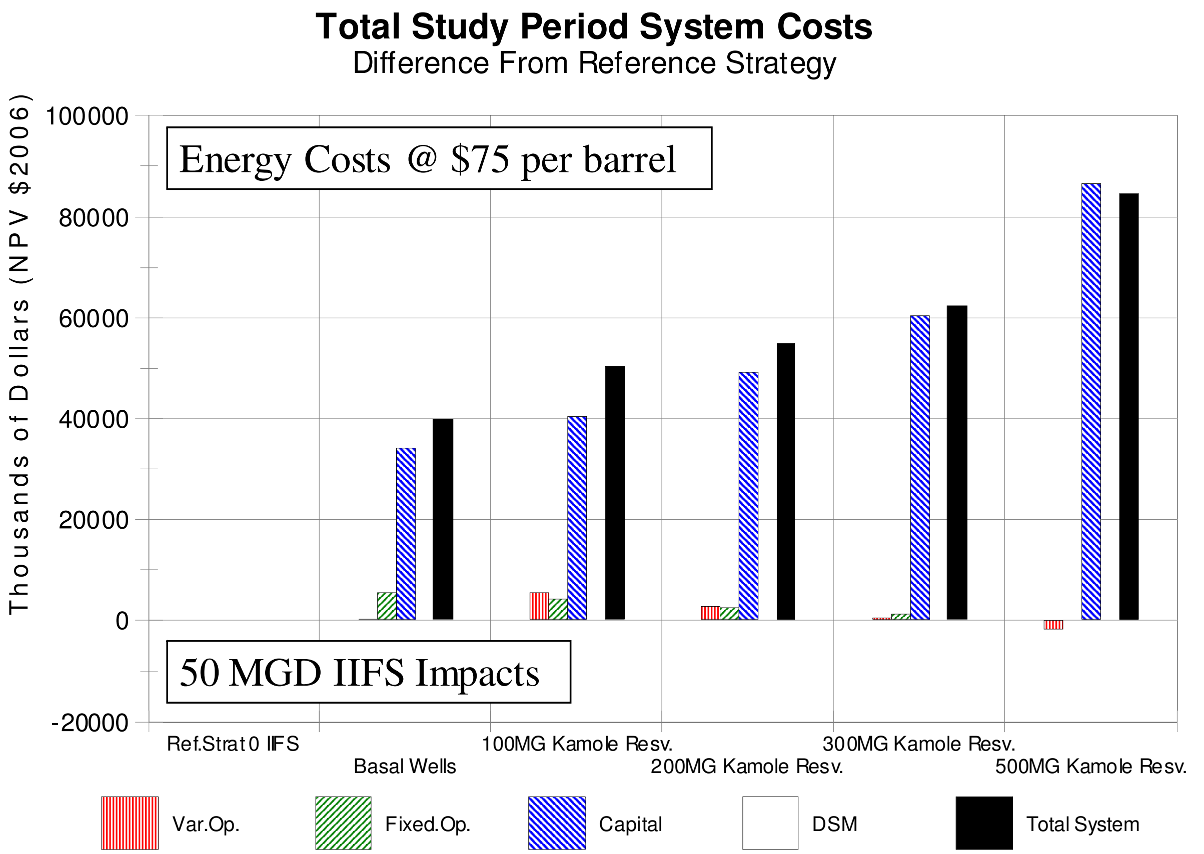


Alternate Upcountry Reservoir Locations and Capacities

50 Year Planning Period NPV Costs; 30 MGD Reduction in Wailoa Ditch base flows; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

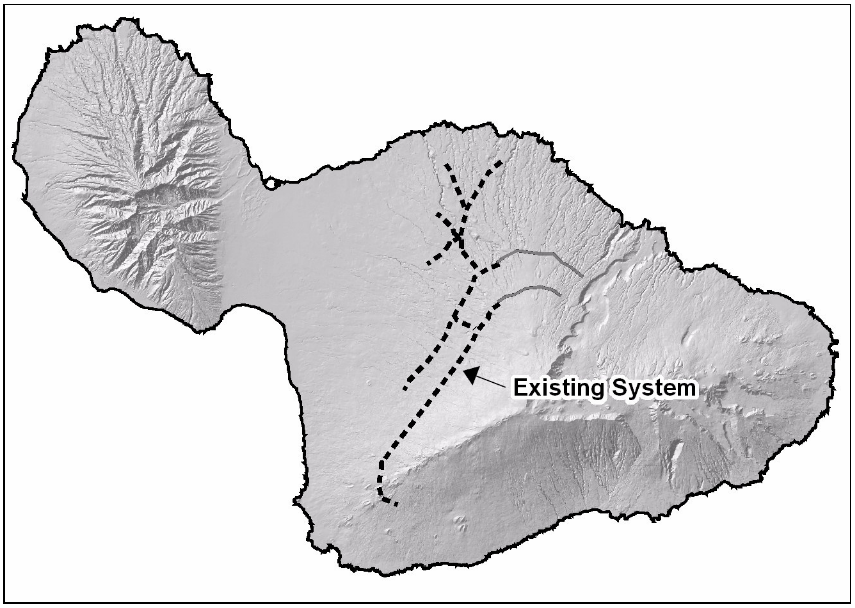
The chart above shows the same strategies assuming a 30 MGD reduction in Wailoa Ditch base flows resulting from implementation of amended IIFS. The low energy scenario is depicted. As in the case of the previous charts the results for the high energy scenario is very similar and is not provided here.

With a 30 MGD reduction in Wailoa Ditch base flows the cost effectiveness of providing drought period reliable capacity is reduced for all sizes of reservoirs. This is because the base flows are reduced to the extent that more reservoir capacity is necessary to provide an equivalent amount of drought period reliable capacity. A 200 MG reservoir is necessary to maintain approximately the same level of Kamole WTP drought period reliability presuming historical base flows.



Alternate Upcountry Reservoir Locations and Capacities
50 Year Planning Period NPV Costs; 50 MGD Reduction in Wailoa Ditch base flows; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies assuming a 50 MGD reduction in Wailoa Ditch base flows resulting from implementation of IIFS amendments. With this amount of reduction in base flows it is not practical to provide drought period reliable capacity using raw water storage for the Kamole WTP. Providing drought period reliability using addition of basal groundwater wells is more cost effective.



E. Limited Growth With Extensive Conservation Measures

Summary

This general strategy examined several possible strategies to limit the water consumption demands on the Upcountry District system. One set of options examined the impacts of limiting or relocating future growth. Another set of options examined Demand-Side Management (conservation) programs to increase the efficiency of water uses. The original concept of this strategy was to meet all new water demands for the Upcountry District by these two strategy components. Although both of these components may play some part in the long range plans of the Upcountry District, these measures alone are not a feasible means to meet the water demands of this region for the 25 year planning period.

Limiting or relocating growth is outside the direct authority of the DWS. Examining the impacts of new growth, however, provides useful information to land use planners and decision makers. One overall conclusion from this examination is that new growth on the Upcountry District system is very expensive. The capital costs associated with providing water for future needs on all of the Upcountry systems far exceed the existing System Development Fees charged for new water services.

Because development and operation of new water sources is very expensive, the Demand-Side Management (DSM) programs that were analyzed are cost effective. Even quite aggressive and relatively expensive programs are cost-effective. After evaluation of the more aggressive DSM programs considered in this strategy it was decided to include some of these more intensive and extensive programs as a component in all of the final candidate strategies.

Project Design Scenarios

There are two principal components to this strategy. One component examines the impacts of limiting or re-distributing growth in water demand. The second component examines the costs and benefits of more extensive demand-side management (conservation) measures. Both of these components focus on reducing water production requirements for one or more of the Upcountry District water systems.

Limiting Growth

Limiting growth in water demand was first examined from an overall District perspective. The obvious conclusion of this analysis was that, of course, reducing water demands by limiting growth reduces water system costs. A meaningful result of the analysis was a quantification of the costs of new growth on the Upcountry systems.

Methods of limiting growth were not examined specifically but could include land use planning decisions or restriction on new or existing water uses.

Redistributing Growth

The effects of redistributing future growth from one Upcountry water system to another was examined to determine the relative costs to serve new water demand on each of the subsystems. This is presented in the Economic Analysis section below.

Extensive Conservation

One realistic strategy within the authority and mission of the DWS would be to implement programs to promote the efficient use water. In the original configuration all of the final candidate strategies a basic portfolio of DSM programs was included based on previous analysis that showed these programs to be cost-effective. This final candidate strategy examined DSM portfolios that are more extensive, more expensive and are designed to reduce water demand by substantially greater amounts. After analysis and consideration of the planning objectives it was decided to include a more extensive conservation program portfolio as a fundamental component of all of the final candidate strategies. In effect, this strategy has been partly incorporated in all of the other final candidate strategies. The basis for this decision is presented below in the Economic Analysis section of this strategy.

Water Conservation Program Options

Conservation programs can be designed with various levels of intensity. Programs can be designed to reach increasing proportions of conservation technical potential by providing more extensive program delivery mechanisms and by targeting progressively more expensive potential water saving fixtures, appliances and irrigation system improvements. Conservation programs can also be designed either to attain water savings at less cost to the utility by implementing programs at a slower pace (such as rebate programs) or, alternatively, by accelerating the program water savings by more intensive and more expensive methods (such as direct installation programs).

A series of alternative conservation program implementation scenarios was examined in each of the rounds of analysis of the final candidate strategies. In the most recent round of analysis several implementation scenarios were examined with respect to several assumptions regarding future energy prices. The programs designed to reach 45% of conservation technical potential in ten years that were assumed in the previous rounds of analysis for this strategy were retained and also made part of all of the principal final candidate strategies presented in this report.

It should be noted that the first steps recommended to implement any of the conservation program scenarios are similar. It would be prudent and economical to be diligent but careful and methodical about establishing an aggressive DSM implementation capability in the DWS. The intensity of program implementation can be adjusted as experience with program implementation is attained and as future uncertain water needs and supply option situations continue to develop.

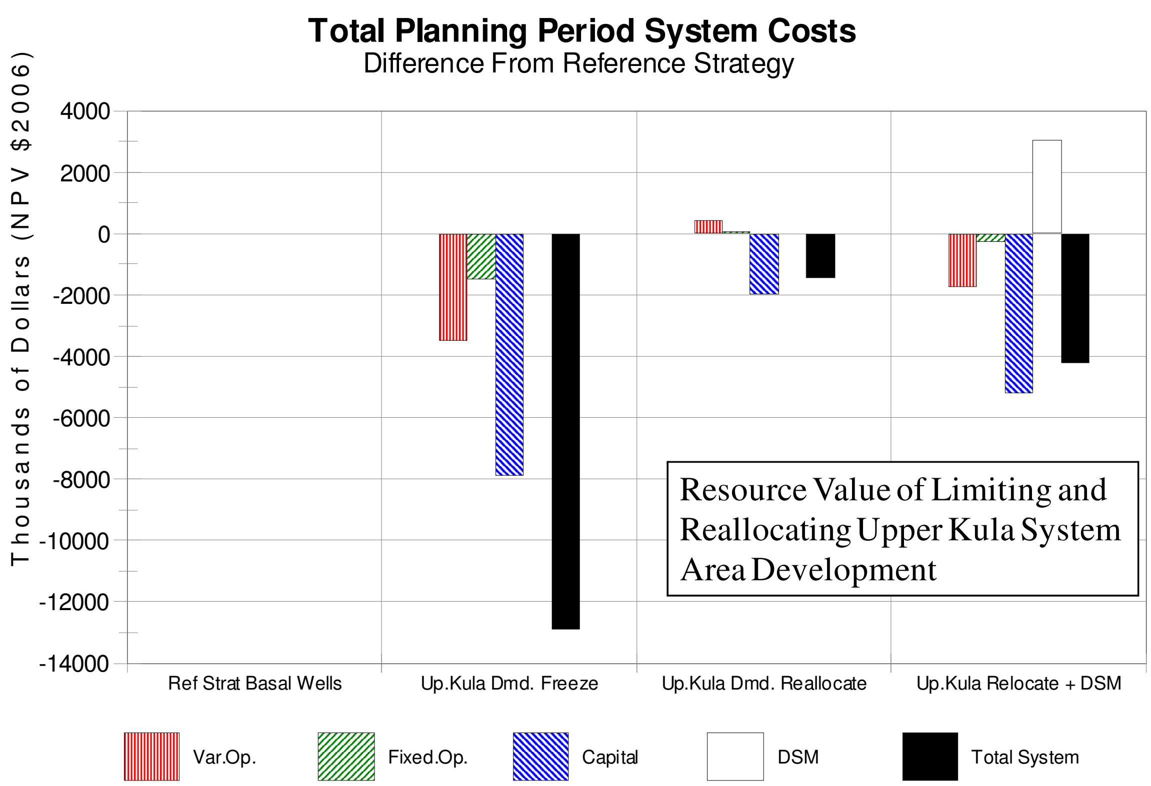
Policy and Feasibility Considerations

Limiting or Redistributing Growth

Limiting or redistributing growth is not considered to be a feasible strategy for the DWS. Information provided by the analyses in this strategy may be considered in the land use planning process.

Conservation and DSM Policy Issues

Several policy issues are discussed in the earlier section of this report "Demand-Side Management (Conservation) Programs" in the presentation of "Independent Components Considered in All Strategies". Policy issues include consideration of (a) impacts of DSM programs on water rates, equity, (2) fairness in programs funded by all customers that provide benefits primarily to program participants and (3) consideration of mandatory codes or restrictions in lieu of funded DSM programs.



Resource Value of Limiting or Relocating Upper Kula System Area Development
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Economic Analysis

Limiting or Relocating Growth in Demand

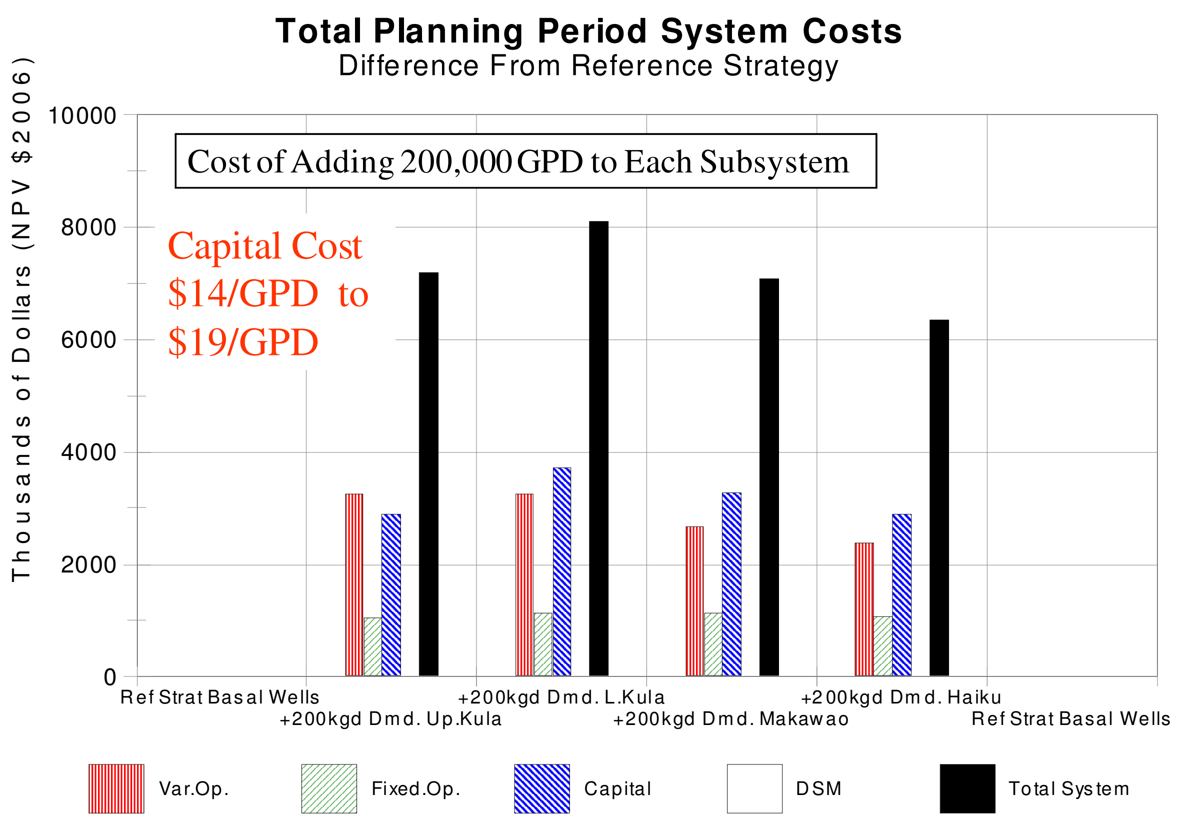
The chart above compares several scenarios that limit or redistribute Upcountry District system growth assumed in the reference strategy. The chart shows total Upcountry District system costs for the 25 year planning period.

The "Upper Kula Demand Freeze" scenario shows the impacts on the planning period system costs if water demand on the upcountry system were to remain constant at existing levels throughout the planning period. This scenario is different than the other scenarios depicted in the respect that less water needs are met. Although costs are lower, so is the benefit provided.

The "Upper Kula Demand Reallocate" scenario shows the planning period costs if the growth that is predicted to occur on the Upper Kula system is instead relocated to the Makawao system.

The “Upper Kula Relocate plus DSM” scenario shows the planning period costs of the previous scenario with the incorporation of DSM programs.

In all of these scenarios the total costs are reduced, primarily due to reduced capital costs to install basal wells. Note that the DSM program portfolio is more effective at reducing system costs than reallocating growth but requires substantial program expenditures.



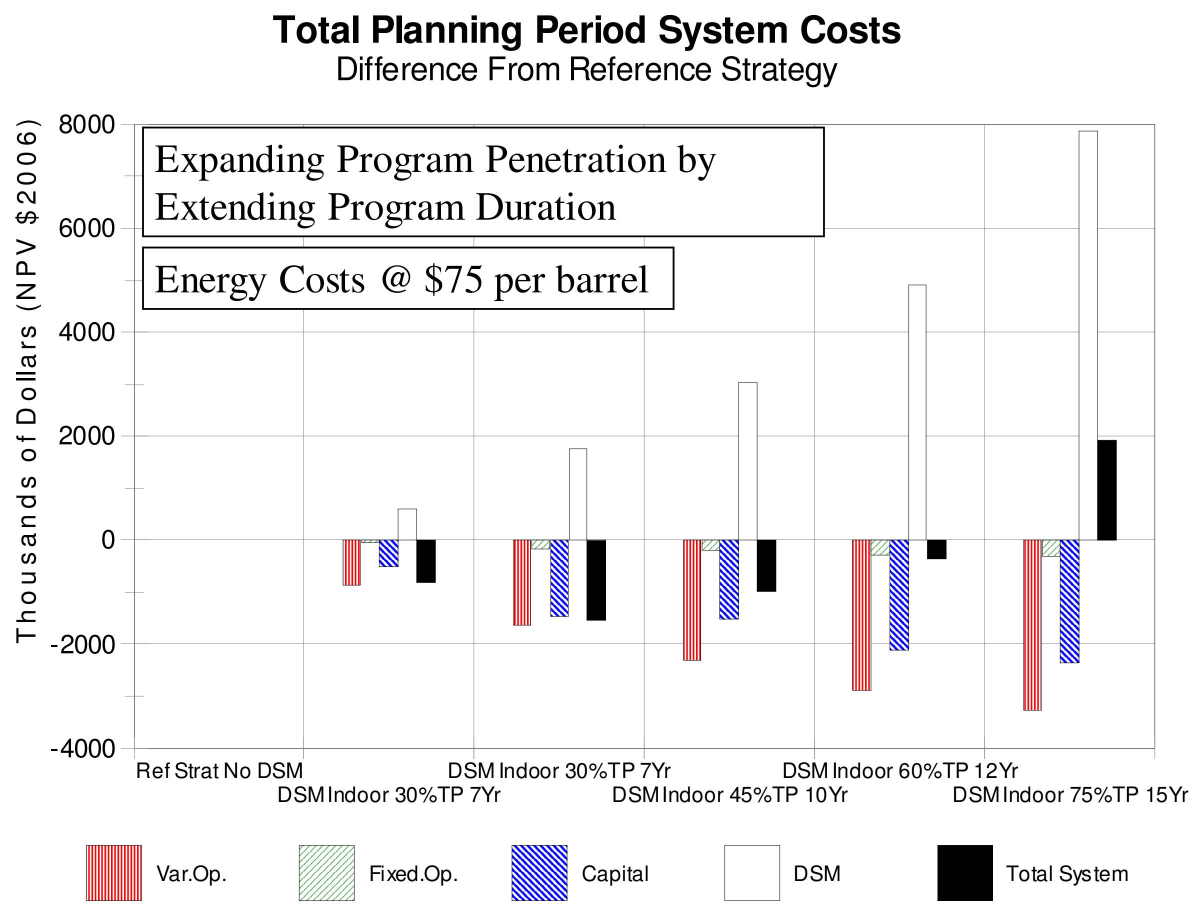
Cost of Adding 200,000 GPD to Each Upcountry Subsystem
25 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

Incremental Cost of New Upcountry Water Service

The chart above shows an analysis of the incremental costs to provide new water service for each of the Upcountry District water systems. The chart shows the total system costs for the 25 year planning period assuming the low energy cost scenario. The incremental costs were determined by comparing the reference strategy to four scenarios in which the future water demand on each of the four district subsystems were increased by 200,000 gallons per day. The analysis shows the cost of serving new water demand on each system.

As highlighted on the chart, the capital costs associated with new water services is between $14 to $19 per gallon per day for the four systems. For a typical 600 gallon per day new service connection this averages over $9,000 for the capital costs to provide necessary system source improvements. Existing System Development Fees collected for this purpose are a small fraction of this cost.

The simple conclusion of this analysis is that growth in water demand on the Upcountry District systems is very expensive.



Expanding Program Penetration by Extending Program Duration
25 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.r

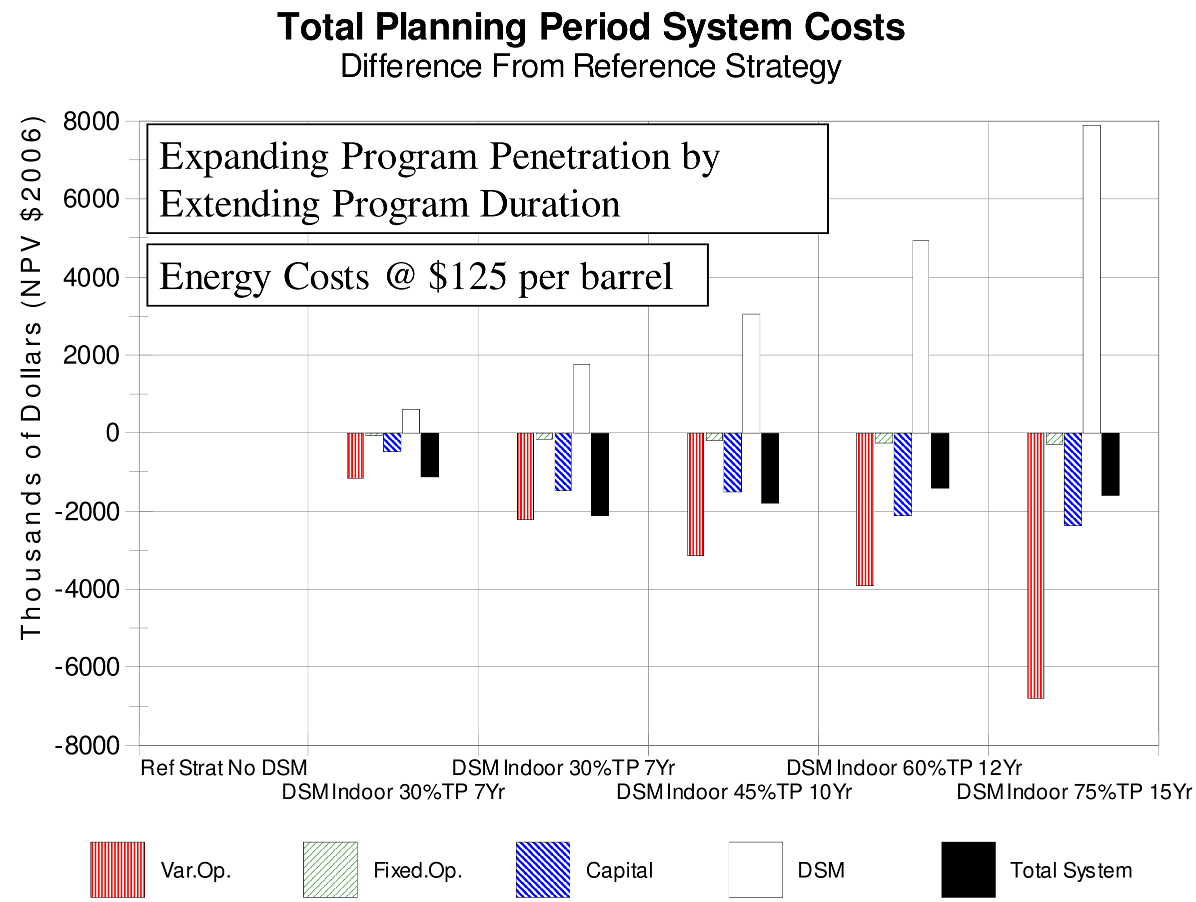
Extensive Conservation

A detailed description of the economic analysis of conservation programs is provided in Appendix A to this report. Because the costs to serve new water demands on the Upcountry District system are high, fairly aggressive (and costly) conservation programs are cost effective.

The chart above shows the DSM costs and resulting planning period cost impacts of implementing an indoor DSM program with increasing duration and an increasing portfolio of measures. The base program attains 15% of the DSM technical potential in five years. Alternate levels of implementation attain 30%, 45%, 60% and 75% of the DSM technical potential in seven, ten, twelve and fifteen years respectively. The longer duration programs include progressively higher levels of incentives, more expensive delivery mechanisms and more expensive measures in later years to achieve higher levels of program participation.

This analysis demonstrates that increasing the duration and intensity of program implementation yields diminishing returns. This is expected since it is necessary to employ more expensive program delivery mechanisms and to target more expensive water saving measures in order to achieve higher proportions of DSM technical potential. In this analysis a twelve year program to attain 60% DSM technical potential is cost effective but a fifteen year program to attain 75% DSM technical potential is not.

expanding Program Penetration by Extending Program Duration, low energy cost scenario.



Expanding Program Penetration by Extending Program Duration
50 Year Planning Period NPV Costs; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the analysis of the same programs assuming the high energy price scenario. Because of the high costs of pumping water to serve Upcountry water demands, even very expensive DSM programs are cost-effective if energy prices are high.

Additional analyses are presented in Appendix A that examine DSM programs designed to attain various levels of demand reduction more quickly than the programs portrayed here.

Based on the economic analyses, the final candidate stratifies for the Upcountry District include the portfolio of programs targeting attainment of 45% of the indoor conservation technical potential in ten years of program implementation. The Recommended Upcountry District Plan presented in this report recommends that final determinations of the best portfolio of conservation measures and programs should be determined based on further analysis incorporating expert assistance and information from specific proposals by potential program implementors.

Comparison of Final Candidate Strategies

The CWRM Framework provides for an Integrated Resource Planning (IRP) process that begins by identifying planning objectives and an assessment of future water needs. Various resources and strategies to meet these objectives are identified, characterized and analyzed. The selection of the best strategies is based on the extent to which they meet the planning objectives identified at the beginning and during the course of the IRP process. In this section the final candidate strategies are evaluated with respect to the planning objectives identified for the Upcountry District.

Planning Objectives and Attributes Matrix

A difficult task in long range planning is presenting a large volume of information about complex issues regarding several alternatives in a way that is, at the same time, comprehensive, meaningful and understandable. It is a challenge to consider and present all necessary factors that need to be considered without creating confusing complexity. Indeed, this is one of the reasons that IRP incorporates the identification and application of planning objectives. This approach ensures that a wide spectrum of factors will be considered and encourages a methodical examination of the merits of the candidate strategies.

Early in the Upcountry District public process, a matrix was developed to consider how each of an extensive list of resource options might affect each of the planning objectives.[15] This served as a tool to elicit comments regarding each of the resources that was considered. A similar matrix format was used in the evaluation of the candidate strategies with each "cell" of the matrix colored to indicate positive impacts, caution and probable negative impacts (green, yellow and red, respectively). In preparing this report the Candidate Strategies matrix was developed in more detail for the Final Candidate Strategies by providing a short text description of impacts in each applicable cell.

The objective of using a matrix approach is ultimately to present enough information to make meaningful decisions by "getting everything on the same page". The problem with this approach is that, even though the information provided in each cell is a very brief synopsis, the size of the matrix tends to get big and/or the type size tends to get small. The matrix is a helpful tool but is difficult to present "all-on-one-one-page" in the letter size format of this report. The matrix is presented in six sections on the following pages. A one page version of the matrix is also provided in scalable format which can be examined or printed in larger scale in the electronic PDF version of this report but will be illegible in the hard copy of the report.

15. Samples of the earlier matrix format are provided in the Resource Options Chapter of the Upcountry District WUDP, August 24, 2005.

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES		Sufficient Water Supply			
	Viability	**Municipal**	**DHHL**	**Agriculture**	**Cost**
	Establish Viable Plans	Adequate Volume of Water for Municipal Uses	Adequate Volume of Water for DHHL Uses	Adequate Volume of Water for Agricultural Uses	Minimize Cost of Water Supply
CANDIDATE STRATEGIES					
INCREMENTAL BASAL WELL DEVELOPMENT		+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- Moderate project capital costs + High drought period operating costs
EXPANSION OF RAW WATER STORAGE CAPACITY	- Reservoir location needs to consider environmental impacts on sensitive areas - Very high project capital costs	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- High project capital costs + Lowest operating costs
"DROUGHT-PROOF" FULL BASAL WELL BACKUP	- High project capital costs	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- High capital costs for sufficient capacity to provide drought period reliability - High drought period operating costs
EXPANDED KAMOLE WATER TREATEMENT PLANT CAPACITY		+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Economical drought period reliability
LIMITED GROWTH WITH EXTENSIVE CONSERVATION MEASURES	- Growth cannot be limited or relocated by DWS - Relocating growth between Upcountry subsystems is not effective to meet future demand growth	- Strategy would not provide services equivalent to other strategies	+ Strategy provides sufficient water to meet projected demand	- Strategy would not provide services equivalent to other strategies	+ Economical means to meet portion of future demand requirements
EXTENSIVE CONSERVATION MEASURES	+ Strategy is viable provided sufficient budget is provided.	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions		+ Economical means to meet portion of future demand requirements

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Efficiency	Environment	Equity	Sustainablility	Quality
	Maximize the Efficiency of Water Use	Minimize Environmental Impacts	Manage Water Equitably	Maintain Sustainable Resources	Maximize Water Quality
CANDIDATE STRATEGIES					
INCREMENTAL BASAL WELL DEVELOPMENT	- Moderately high energy use	- Construction impacts: wells, transmission pipe, roads, power lines		- Moderately high energy use	
EXPANSION OF RAW WATER STORAGE CAPACITY	+ Reduces water pumping requirements + Reduces energy consumption	- Construction impacts: wells, transmission pipe, roads - Potential impacts on endangered and threatened species depending upon reservoir location	- Export of water for use outside of source aquifer area	+ Prioritizes sustainability + Reduces energy consumption	- Water quality issues associated with surface water
"DROUGHT-PROOF" FULL BASAL WELL BACKUP	- Moderately high energy use	- Construction impacts: wells, transmission pipe, roads, power lines		- Moderately high energy use	
EXPANDED KAMOLE WATER TREATEMENT PLANT CAPACITY	- Moderately high energy use		- Export of water for use outside of source aquifer area		- Water quality issues associated with surface water
LIMITED GROWTH WITH EXTENSIVE CONSERVATION MEASURES	+ Reduces water pumping requirements + Reduces energy consumption			+ Prioritizes sustainability + Reduces water source use + Reduces energy consumption	
EXTENSIVE CONSERVATION MEASURES	+ Reduces water pumping requirements + Reduces energy consumption			+ Prioritizes sustainability + Reduces water source use + Reduces energy consumption	

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Reliability	Streams	Resources	Culture	Conformity
	Maximize Reliability of Water Service	**Protect and Restore Streams**	**Protect Water Resources**	**Protect Cultural Resources**	**Maintain Consistency with General and Community Plans**
CANDIDATE STRATEGIES					
INCREMENTAL BASAL WELL DEVELOPMENT	+ Strategy meets analysis design reliability / capacity expansion criteria		+ Assumes withdrawals within sustainable yields		
EXPANSION OF RAW WATER STORAGE CAPACITY	+ Strategy meets analysis design reliability / capacity expansion criteria	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	+ Assumes withdrawals within sustainable yields		
"DROUGHT-PROOF" FULL BASAL WELL BACKUP	+ Strategy meets analysis design reliability / capacity expansion criteria		+ Assumes withdrawals within sustainable yields		
EXPANDED KAMOLE WATER TREATEMENT PLANT CAPACITY	+ Strategy meets analysis design reliability / capacity expansion criteria	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	+ Assumes withdrawals within sustainable yields	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	
LIMITED GROWTH WITH EXTENSIVE CONSERVATION MEASURES	+ Strategy meets analysis design reliability / capacity expansion criteria	+ Reduces water source use	+ Assumes withdrawals within sustainable yields + Reduces potable water source use		
EXTENSIVE CONSERVATION MEASURES	+ Strategy meets analysis design reliability / capacity expansion criteria	+ Reduces water source use	+ Assumes withdrawals within sustainable yields + Reduces potable water source use		+ Consistent with state and county policies and plans

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Efficiency	Environment	Equity	Sustainablility	Quality
	Maximize the Efficiency of Water Use	Minimize Environmental Impacts	Manage Water Equitably	Maintain Sustainable Resources	Maximize Water Quality
COMPONENTS IN ALL STRATEGIES					
COMMITTED RESOURCE OPTIONS		- Construction impacts: wells, transmission pipe, roads, power lines			
NEAR TERM RESOURCE OPTIONS		- Construction impacts: wells, transmission pipe, roads, power lines			
DEMAND SIDE MANAGEMENT PROGRAMS	+ Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption	- All customers pay for program participant benefits	+ Reduces water source use + Reduces energy consumption	
INDEPENDENT STRATEGY COMPONENTS					
SUPPLY SIDE LEAK REDUCTION	+ Prioritizes efficiency + Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption		+ Reduces water source use + Reduces energy consumption	
ENERGY PRODUCTION AND EFFICIENCY	+ Reduces energy consumption	+ Reduces energy consumption		+ Reduces energy consumption	
STREAM RESTORATION MEASURES		+ Promotes health stream, estuary and reef environment		+ Promotes aquifer recharge + Promotes sustainable kuleana subsistence	+ Promotes water quality for kuleana agricultural uses
WATERSHED PROTECTION AND RESTORATION		+ Improves forest and stream environmental quality		+ Increases useable surface and groundwater aquifer sources	+ Increases quality of stream water
WELL DEVELOPMENT POLICIES AND REGULATIONS		+ Allows planning & siting of new resources considering environmental quality	+ Promotes clear standards for allocation of water supply		+ Allows planning & siting of new resources considering water quality
WELLHEAD PROTECTION ORDINANCE		+ Promotes environmentally sensitive practices in wellhead protection zones	- Could affect existing land uses		+ Protects well sources from contamination from land uses
CONSERVATION ORDINANCE	+ Promotes efficient use of water resources		+ Promotes allocation of water to public trust and beneficial uses - Impacts on existing landscape irrigation users	+ Promotes use of sustainable plantings	
DROUGHT WATER USE RESTRICTIONS	+ Reduces use of expensive resources in times of drought				
WATER RATE DESIGN AND PRICING POLICIES	+ Marginal pricing encourages conservation		- High volume users subsidize low volume users - Municipal users subsidize agricultural	+ Marginal pricing encourages conservation	

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Efficiency	Environment	Equity	Sustainablility	Quality
	Maximize the Efficiency of Water Use	Minimize Environmental Impacts	Manage Water Equitably	Maintain Sustainable Resources	Maximize Water Quality
COMPONENTS IN ALL STRATEGIES					
COMMITTED RESOURCE OPTIONS		- Construction impacts: wells, transmission pipe, roads, power lines			
NEAR TERM RESOURCE OPTIONS		- Construction impacts: wells, transmission pipe, roads, power lines			
DEMAND SIDE MANAGEMENT PROGRAMS	+ Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption	- All customers pay for program participant benefits	+ Reduces water source use + Reduces energy consumption	
INDEPENDENT STRATEGY COMPONENTS					
SUPPLY SIDE LEAK REDUCTION	+ Prioritizes efficiency + Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption		+ Reduces water source use + Reduces energy consumption	
ENERGY PRODUCTION AND EFFICIENCY	+ Reduces energy consumption	+ Reduces energy consumption		+ Reduces energy consumption	
STREAM RESTORATION MEASURES		+ Promotes health stream, estuary and reef environment		+ Promotes aquifer recharge + Promotes sustainable kuleana subsistence	+ Promotes water quality for kuleana agricultural uses
WATERSHED PROTECTION AND RESTORATION		+ Improves forest and stream environmental quality		+ Increases useable surface and groundwater aquifer sources	+ Increases quality of stream water
WELL DEVELOPMENT POLICIES AND REGULATIONS		+ Allows planning & siting of new resources considering environmental quality	+ Promotes clear standards for allocation of water supply		+ Allows planning & siting of new resources considering water quality
WELLHEAD PROTECTION ORDINANCE		+ Promotes environmentally sensitive practices in wellhead protection zones	- Could affect existing land uses		+ Protects well sources from contamination from land uses
CONSERVATION ORDINANCE	+ Promotes efficient use of water resources		+ Promotes allocation of water to public trust and beneficial uses - Impacts on existing landscape irrigation users	+ Promotes use of sustainable plantings	
DROUGHT WATER USE RESTRICTIONS	+ Reduces use of expensive resources in times of drought				
WATER RATE DESIGN AND PRICING POLICIES	+ Marginal pricing encourages conservation		- High volume users subsidize low volume users - Municipal users subsidize agricultural users	+ Marginal pricing encourages conservation	

CENTRAL DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Reliability	Streams	Resources	Culture	Conformity
	Maximize Reliability of Water Service	Protect and Restore Streams	Protect Water Resources	Protect Cultural Resources	Maintain Consistency with General and Community Plans
COMPONENTS IN ALL STRATEGIES					
COMMITTED RESOURCE OPTIONS	+ These resources are necessary to provide sufficient production and capacity				
NEAR TERM RESOURCE OPTIONS	+ These resources are necessary to provide sufficient production and capacity				
DEMAND SIDE MANAGEMENT PROGRAMS	+ Provides short and mid-term system reliability benefits	+ Reduces source water use	+ Reduces source water use		+ Consistent with state and county policies and plans
INDEPENDENT STRATEGY COMPONENTS					
SUPPLY SIDE LEAK REDUCTION	+ Provides short and mid-term system reliability benefits	+ Reduces source water use	+ Reduces source water use		
ENERGY PRODUCTION AND EFFICIENCY					
STREAM RESTORATION MEASURES		+ Prioritizes & promotes healthy streams	+ Increases capture of precipitation and aquifer recharge	+ Promotes healthy streams and provides water for kuleana agriculture	
WATERSHED PROTECTION AND RESTORATION		+ Promotes healthy streams	+ Increases capture of precipitation and aquifer recharge	+ Promotes healthy streams and provides water for kuleana agriculture	
WELL DEVELOPMENT POLICIES AND REGULATIONS	+ Allows planning & siting of new resources considering system integration issues		+ Allows planning & siting of new resources considering protection of water resources	+ Allows planning & siting of new resources considering protection of cultural resources	+ Allows planning & siting of new resources considering general and community plans
WELLHEAD PROTECTION ORDINANCE			+ Protects well sources from contamination from land uses		
CONSERVATION ORDINANCE		+ Reduces source water use	+ Reduces source water use		
DROUGHT WATER USE RESTRICTIONS	+ Increases drought period system reliability	+ Reduces source water use when sources have lowest yields	+ Reduces source water use when sources have lowest yields		
WATER RATE DESIGN AND PRICING POLICIES	+ Provides short and mid-term system reliability benefits				

UPCOUNTRY DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Planning Objectives														
		Sufficient Water Supply													
	Viability	Municipal	DHHL	Agriculture	Cost	Efficiency	Environment	Equity	Sustainablility	Quality	Reliability	Streams	Resources	Culture	Conformity
	Establish Viable Plans	Adequate Volume of Water for Municpal Uses	Adequate Volume of Water for DHHL Uses	Adequate Volume of Water for Agricultural Uses	Minimize Cost of Water Supply	Maximize the Efficiency of Water Use	Minimize Environmental Impacts	Manage Water Equitably	Maintain Sustainable Resources	Maximize Water Quality	Maximize Reliability of Water Service	Protect and Restore Streams	Protect Water Resources	Protect Cultural Resources	Maintain Consistency with General and Community Plans
CANDIDATE STRATEGIES															
INCREMENTAL BASAL WELL DEVELOPMENT		+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- Moderate project capital costs + High drought period operating costs	- Moderately high energy use	- Construction impacts: wells, transmission pipe, roads, power lines		- Moderately high energy use		+ Strategy meets analysis design reliability / capacity expansion criteria		+ Assumes withdrawals within sustainable yields		
EXPANSION OF RAW WATER STORAGE CAPACITY	- Reservoir location needs to consider environmental impacts on sensitive areas - Very high project capital costs	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- High project capital costs + Lowest operating costs	+ Reduces water pumping requirements + Reduces energy consumption	- Construction impacts: wells, transmission pipe, roads - Potential impacts on endangered and threatened species depending upon reservoir location	- Export of water for use outside of source aquifer area	+ Prioritizes sustainability + Reduces energy consumption	- Water quality issues associated with surface water	+ Strategy meets analysis design reliability / capacity expansion criteria	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	+ Assumes withdrawals within sustainable yields		
"DROUGHT-PROOF" FULL BASAL WELL BACKUP	- High project capital costs	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides sufficient water to meet projected demand	+ Strategy provides additional drought period water availability but water supply for agricultural uses remains limited	- High capital costs for sufficient capacity to provide drought period reliability - High drought period operating costs	- Moderately high energy use	- Construction impacts: wells, transmission pipe, roads, power lines		- Moderately high energy use		+ Strategy meets analysis design reliability / capacity expansion criteria		+ Assumes withdrawals within sustainable yields		
EXPANDED KAMOLE WATER TREATEMENT PLANT CAPACITY		+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Economical drought period reliability	- Moderately high energy use		- Export of water for use outside of source aquifer area		- Water quality issues associated with surface water	+ Strategy meets analysis design reliability / capacity expansion criteria	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	+ Assumes withdrawals within sustainable yields	- Additional use of stream water for municipal purposes could increase competition for stream water allocations	
LIMITED GROWTH WITH EXTENSIVE CONSERVATION MEASURES	- Growth cannot be limited or relocated by DWS - Relocating growth between Upcountry subsystems is not effective to meet future demand growth	- Strategy would not provide services equivalent to other strategies	+ Strategy provides sufficient water to meet projected demand	- Strategy would not provide services equivalent to other strategies	+ Economical means to meet portion of future demand requirements	+ Reduces water pumping requirements + Reduces energy consumption			+ Prioritizes sustainability + Reduces water source use + Reduces energy consumption		+ Strategy meets analysis design reliability / capacity expansion criteria	+ Reduces water source use	+ Assumes withdrawals within sustainable yields + Reduces potable water source use		
EXTENSIVE CONSERVATION MEASURES	+ Strategy is viable provided sufficient budget is provided.	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions	+ Strategy provides sufficient water to meet projected demand but only in conjuction with other additional source additions		+ Economical means to meet portion of future demand requirements	+ Reduces water pumping requirements + Reduces energy consumption			+ Prioritizes sustainability + Reduces water source use + Reduces energy consumption		+ Strategy meets analysis design reliability / capacity expansion criteria	+ Reduces water source use	+ Assumes withdrawals within sustainable yields + Reduces potable water source use		+ Consistent with state and county policies and plans

UPCOUNTRY DISTRICT FINAL CANDIDATE STRATEGIES ATTAINMENT OF PLANNING OBJECTIVES	Planning Objectives														
		Sufficient Water Supply													
	Viability	Municipal	DHHL	Agriculture	Cost	Efficiency	Environment	Equity	Sustainablility	Quality	Reliability	Streams	Resources	Culture	Conformity
	Establish Viable Plans	Adequate Volume of Water for Municpal Uses	Adequate Volume of Water for DHHL Uses	Adequate Volume of Water for Agricultural Uses	Minimize Cost of Water Supply	Maximize the Efficiency of Water Use	Minimize Environmental Impacts	Manage Water Equitably	Maintain Sustainable Resources	Maximize Water Quality	Maximize Reliability of Water Service	Protect and Restore Streams	Protect Water Resources	Protect Cultural Resources	Maintain Consistency with General and Community Plans
COMPONENTS IN ALL STRATEGIES															
COMMITTED RESOURCE OPTIONS		+ These resources are necessary to provide sufficient production and capacity	+ These resources are necessary to provide sufficient production and capacity				- Construction impacts: wells, transmission pipe, roads, power lines				+ These resources are necessary to provide sufficient production and capacity				
NEAR TERM RESOURCE OPTIONS	- Some uncertainty regarding timely implementation of Waikapu South #2 Well assumed to be online in integration analyses	+ These resources are necessary to provide sufficient production and capacity	+ These resources are necessary to provide sufficient production and capacity				- Construction impacts: wells, transmission pipe, roads, power lines				+ These resources are necessary to provide sufficient production and capacity				
DEMAND SIDE MANAGEMENT PROGRAMS	+ Can be implemented immediately without permitting barriers	+ Provides short and mid-term benefit to meet water demands	+ Provides short and mid-term benefit to meet water demands	+ Provides short and mid-term benefit to meet water demands	+ Reduces system costs + Reduces customer costs - Upward pressure on unit rates	+ Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption	- All customers pay for program participant benefits	+ Reduces water source use + Reduces energy consumption		+ Provides short and mid-term system reliability benefits	+ Reduces source water use	+ Reduces source water use		+ Consistent with state and county policies and plans
INDEPENDENT STRATEGY COMPONENTS															
SUPPLY SIDE LEAK REDUCTION		- Provides short and mid-term benefit to meet water demands	- Provides short and mid-term benefit to meet water demands		+ Reduces system costs + Reduces customer costs	+ Prioritizes efficiency + Reduces water source use + Reduces energy consumption	+ Reduces water source use + Reduces energy consumption		+ Reduces water source use + Reduces energy consumption		+ Provides short and mid-term system reliability benefits	+ Reduces source water use	+ Reduces source water use		
ENERGY PRODUCTION AND EFFICIENCY					+ Reduces system costs + Reduces customer costs	+ Reduces energy consumption	+ Reduces energy consumption		+ Reduces energy consumption						
STREAM RESTORATION MEASURES	+ County WUDP can make recommendations and state policy but authority rests with CWRM			+ Provides water for kuleana and subsistance agriculture - Reduces water supply for Upcountry and Central Maui large agriculture			+ Promotes health stream, estuary and reef environment		+ Promotes aquifer recharge + Promotes sustainable kuleana subsistence	+ Promotes water quality for kuleana agricultural uses		+ Prioritizes & promotes healthy streams	+ Increases capture of precipitation and aquifer recharge	+ Promotes healthy streams and provides water for kuleana agriculture	
WATERSHED PROTECTION AND RESTORATION		+ Increases useable surface and groundwater aquifer sources	+ Increases useable surface and groundwater aquifer sources	+ Increases useable surface and groundwater aquifer sources	- Programs cost money		+ Improves forest and stream environmental quality		+ Increases useable surface and groundwater aquifer sources	+ Increases quality of stream water		+ Promotes healthy streams	+ Increases capture of precipitation and aquifer recharge	+ Promotes healthy streams and provides water for kuleana agriculture	
WELL DEVELOPMENT POLICIES AND REGULATIONS	+ Clear policies promote contract approvals	+ Clear policies encourage investment and promote contract approvals	+ Clear policies encourage investment and promote contract approvals				+ Allows planning & siting of new resources considering environmental quality	+ Promotes clear standards for allocation of water supply		+ Allows planning & siting of new resources considering water quality	+ Allows planning & siting of new resources considering system integration issues		+ Allows planning & siting of new resources considering protection of water resources	+ Allows planning & siting of new resources considering protection of cultural resources	+ Allows planning & siting of new resources considering general and community plans
WELLHEAD PROTECTION ORDINANCE							+ Promotes environmentally sensitive practices in wellhead protection zones	- Could affect existing land uses		+ Protects well sources from contamination from land uses			+ Protects well sources from contamination from land uses		
LANDSCAPE ORDINANCE		- Limits water use for landscape irrigation + Increases availability for other uses	- Limits water use in times of drought	+ Increases water availability in times of drought		+ Promotes efficient use of water resources		+ Promotes allocation of water to public trust and beneficial uses - Impacts on existing landscape irrigation users	+ Promotes use of sustainable plantings			+ Reduces source water use	+ Reduces source water use		
DROUGHT WATER USE RESTRICTIONS		- Limits water use in times of drought	- Limits water use in times of drought	+ Increases water availability in times of drought	+ Allows maintenance of reliable water supply at reasonable cost	+ Reduces use of expensive resources in times of drought					+ Increases drought period system reliability	+ Reduces source water use when sources have lowest yields	+ Reduces source water use when sources have lowest yields		
WATER RATE DESIGN AND PRICING POLICIES		+ Marginal pricing encourages conservation	+ Marginal pricing encourages conservation	+ Agricultural water rates are subsidized		+ Marginal pricing encourages conservation		- High volume users subsidize low volume users - Municipal users subsidize agricultural users	+ Marginal pricing encourages conservation		+ Provides short and mid-term system reliability benefits				

This chart is not legible printed at letter size but can be viewed or printed from electronic PDF file format.

Uncertainty and Contingency Planning

There are substantial uncertainties regarding several factors that are important to consider in determining recommended water resource plans. Some factors, such as future energy prices and the rate of future growth in water demand, are particularly uncertain at this time of pronounced economic upheaval. Some uncertainties have been examined to some extent by testing alternate scenarios in the integrated economic analyses presented in this report. Some remaining uncertainties are addressed by a “contingency planning” approach identifying specific measures to address uncertainties and maintain optimal planning flexibility.

Uncertainty Regarding the Viability of Strategies

The viability of several of the final candidate strategies is uncertain to some extent.

- The feasible size and location of a new raw water storage reservoir on the Lower Kula system are uncertain. The location of a reservoir to serve the Piiholo WTP must be at a specific elevation in order to function properly and efficiently in conjunction with the existing diversion structures, transmission, reservoir and WTP. Several areas to the east of the existing reservoir would be preferred for topographic and hydraulic system design reasons. It may not be desired or feasible to site a reservoir to the east.existing reservoir, however, because this area is very sensitive environmentally. Locating a new reservoir near the existing reservoir or further to the west would have less environmental impact but may limit the feasible reservoir size.
- The capital costs associated with the raw water storage reservoirs considered in this report are substantial. All of the Upcountry strategies that include new raw water storage include total near term capital requirements in excess of $50 million. Some strategies would require more than $100 million of capital projects. In conjunction with projects required on other DWS district systems, total capital requirements for projects necessary in the near term could easily exceed $100 and total as much as $200 million. The feasibility of providing funds for all of these large construction projects has not been determined.
- Although there is general confidence that sufficient productive sites for new basal groundwater wells will be available to serve the municipal needs of the Upcountry district, this in not certain. The efficacy and water quality of individual wells in the Haiku aquifer have proven to be uncertain. In some cases wells drilled in relatively close proximity have proven to be very different in terms of usability.

Resource Implementation Lead Times and Project Phasing

The amount of time between a decision to proceed with a water resource development project and the date it goes into productive service is uncertain and can be several years. The magnitude and uncertainty in resource project lead times presents several challenges in economic analysis and in plan implementation.

The analyses presented in this report presume that new resources necessary to provide reliable water service can be built within estimated time frames. Initial analyses assumed that resources could be implemented promptly so that the integration modelling could effectively compare the “ideal” economics of alternate strategies without regard to project timing and phasing constraints. Additional analyses were conducted to examine estimated feasible dates for resource implementation to asses impacts on economics and maintenance of system reliability.

In all of the analyses it was determined that the drought period reliability of the Upcountry system is currently deficient. Aside from any technical analysis, this is deficiency is very clear to upcountry residents who are occasionally asked to conserve water during extended dry periods due to low water supply reservoir levels. Some of the featured resource options in the strategies examined in this report would not commence production for an extended period of time, even if a commitment to proceed diligently were made today. One important question is what would happen in the intervening years before the options selected in the WUDP process could be put in service. What contingency measures should be taken to maintain and expand water service capability in the immediate term?

Water conservation programs and measures that could be taken on the “customers’ side of the meter” are clearly measures that could provide relief in a one to two year time frame. Improvements to the intake structures at the Kamole WTP are another short term option. New basal groundwater wells installed by private developers may provide some interim resources and drought period backup capacity. Concurrent with implementation of these short term measures, however, it is expected that there will be reductions in the amount of water in the Wailoa Ditch that serves the Kamole WTP resulting from implementation of the amended IIFS on East Maui streams that feed the Koolau/Wailoa Ditch system.

In conjunction with the substantial lead times associated with substantial new resource additions, it is clear that, for at least several more years, the Upcountry system may have to endure water use restrictions if extended periods of particularly dry conditions occur. It is also clear that, unless the implementation of new resources is successfully expedited, substantial progress on allowing substantial numbers of new meters to potential customers on the “Upcountry waiting list” will remain several years in the future.

The substantial and uncertain lead times for implementing new raw water storage reservoirs also pose some analytical planning issues. The economic analyses presented in this report examine and compare different resource development strategies. One primary focus is on comparing different raw water storage reservoir options with development of extensive basal groundwater wells to provide drought period reliability. The economic analyses of raw water storage reservoirs presented in this report consider the economics of expected improvements in system operation efficiency. The analyses also presume that building expensive reservoirs would allow the costs of redundant backup groundwater wells to be avoided or deferred. Since the lead times associated with design, permitting, construction and commissioning these reservoirs are extensive, it is not clear that the assumed benefits of avoiding extra basal well development would be realized. Basal groundwater wells might be installed incrementally in intervening years, thus adding to the ultimate cost of the raw water storage strategies.

The impacts of project timing constraints are examined in the following section of this report. This examination indicates that without consideration of constraints on project timing a reservoir at the Kamole WTP would cost less than providing alternative drought period reliable capacity by addition of a series of basal groundwater wells. This result is only true, however, If the addition of basal wells can be deferred until a reservoir can be put into service. If a substantial number of basal wells is added to the system in the interim period prior to commissioning a reservoir, the cost effectiveness of the reservoir strategy is diminished. It would not be beneficial or cost effective to provide duplicative drought period reliable capacity with both a Kamole reservoir and a series of basal wells.

Uncertainty Regarding Energy Prices

Electrical energy costs are the single largest ongoing expense of the DWS. The DWS is the single largest customer of the Maui Electric Company. Future electrical prices are an important determinant in the economic analysis comparing the merits of the final candidate strategies.

The year 2008 has seen the most volatile world energy prices in history. In the first half of the year world oil prices doubled. In the second half of the year they fell to one third of the peak price. This volatility can be seen in the electrical energy price assumptions incorporated in the concurrent WUDP economic analyses. The analyses of the final candidate strategies was revised to incorporate electrical energy prices at approximately their peak and then revised again as prices fell. This report presents a comparative analysis of the final candidate strategies with respect to a range of prices. This range is wide (equivalent to a range of $75 per barrel to $125 per barrel) but certainly does not bound the range of possible future energy prices. Future energy prices remain substantially and inevitably uncertain.

Energy price uncertainty and volatility affects long range planning decisions and DWS finances. From a planning standpoint, uncertainty regarding future energy prices is addressed by considering the results of the economic analyses of the final candidate strategies assuming different future energy price scenarios. The impacts of energy price volatility on DWS finances could be addressed by rate designs that adjust water rates according to changes in electric rates.

Uncertainty Regarding Project Construction Costs

The estimates of project construction costs in the final candidate strategy analyses were derived from several sources. Historical and recent actual and contractual project costs were examined. Estimates were also obtained from a Maui contractor for a range of possible major capital projects. Despite best efforts, however, the estimates of project costs remain substantially uncertain.

Construction costs on Maui for the past few years have been particularly high compared to historical costs due, at least in part, to high demand for limited construction industry services. Most recently it is expected that project construction costs could soften as demand for construction industry services wanes with economic recession.

Capital Costs and Uncertainty in Future Water Demand

One specific factor that should be considered is the risk associated with strategies, such as the raw water storage reservoir options, that require very large “up front” lump sum capital expenditures that cannot be implemented in phases as demand develops. Some caution is advised regarding commitments to major capital projects at a time of possibly extended economic recession unless the objective (and associated provision of capital funding) is to promote economic stimulus. For the Upcountry District, however, there is clearly a backlog of demand for new water services that will not be extinguished by near term economic conditions. It is also clear that there are substantial long term operation cost benefits associated with implementation of raw water storage, especially additional storage on the Lower Kula system. These circumstances could represent a good opportunity if the slowdown in economic conditions results in lower project construction costs and if contracts can be implemented in time to take advantage of these conditions.

In the analyses presented in this report, all of the strategies are evaluated assuming the consistent growth in water demand associated with the trends assumed in the County’s land use planning analyses. It is assumed in the land use planning analyses that planned land development will result in persistent long term growth in water demand. This is not a certain assumption. It is possible that water demand will not increase at projected rates, or indeed at all, in the next several years due to customer response to higher water prices and economic recession. In a worst case perspective, rate increases resulting from large capital projects could further induce reductions in water demand, resulting in further needs for rate increases.

Magnitude and Timing of Increased Instream Flow Standards on East Maui Streams

Recent and anticipated amendments to the IIFS on East Maui streams will result in decreased base flows in the Wailoa Ditch which is the source of water for the Kamole WTP. The magnitude and timing of additional amendments or future adjustments to the IIFS is not known. Analysis presented in this report (including Appendix C) determined that the anticipated reductions in Wailoa Ditch base flows will require some actions by the DWS in order to maintain the historical level of drought period reliable capacity provided by the Kamole WTP. The impacts of the IIFS will be felt over some uncertain extended period of time as the structural changes to diversions structures on the Koolau/Wailoa Ditch are made to implement return of the base flow of water to the affected streams. Permitting and construction of the changes to the diversion structures may take several years.

If the ultimate reductions in Wailoa Ditch base flow is in the range of 20 MGD it would be more cost effective for the DWS to mitigate these reduced flows by construction of a raw water storage reservoir at the Kamole WTP than it would be to provide additional backup basal groundwater well capacity. If the ultimate reductions to ditch base flow exceed 30 MGD, however, it would not be cost effective to rely on the Wailoa Ditch for reliable capacity by construction of a reservoir to serve the Kamole WTP. If a reservoir is to be the preferred option to mitigate base flow reductions plans to commence design and identify sources of capital funding should proceed promptly. Before a substantial investments are made, however, there should be some resolution or reassurance regarding the ultimate magnitude of IIFS impacts that can realistically be expected in the next several decades.

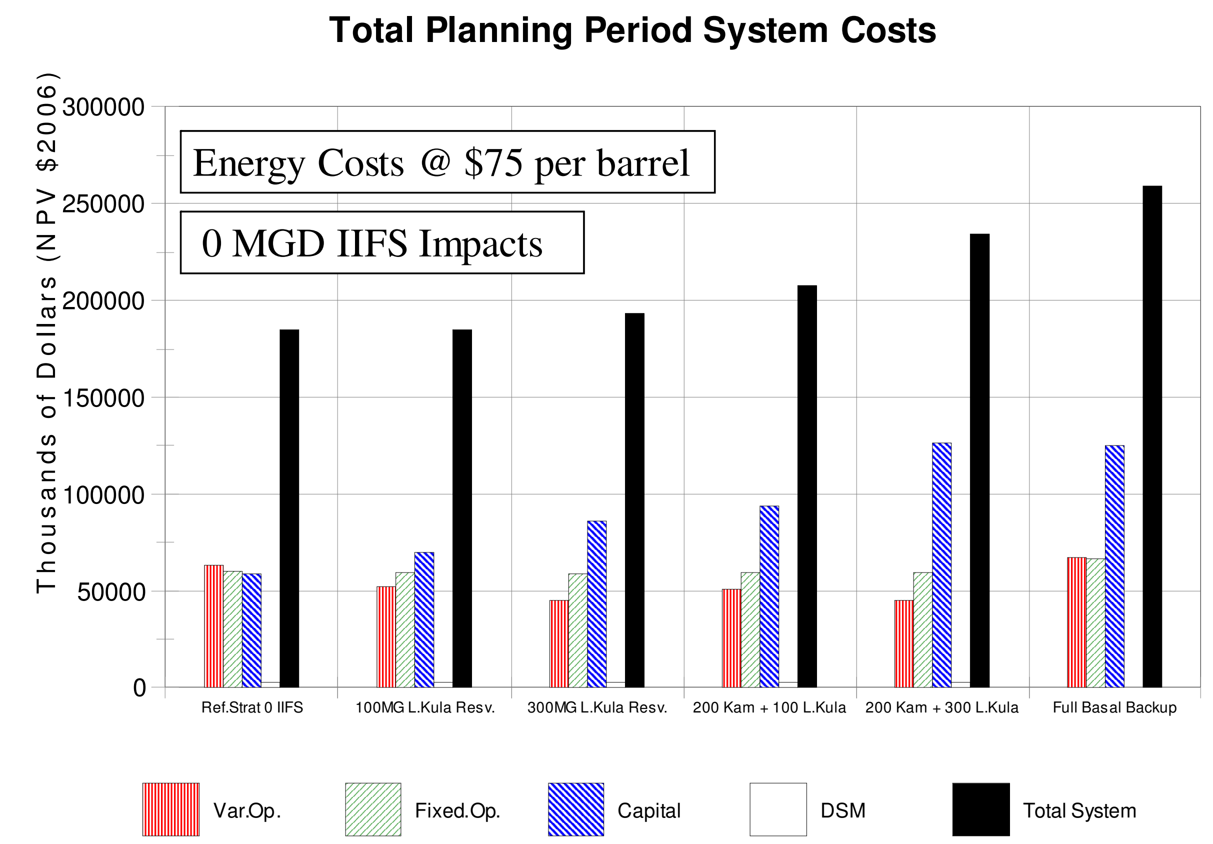
Economic Analysis of the Final Candidate Strategies

In previous sections each of the final candidate strategies is examined regarding several considerations. In this section the final candidate strategies are compared with one another. The analyses in this section are presented several contexts in three sections:

- Initial comparison of the final candidate strategies without explicit consideration of the anticipated reductions in Wailoa Ditch base flows resulting from amendments to the IIFS on East Maui streams.
- Comparison of selected final candidate strategies considering a 20 MGD reduction in Wailoa Ditch base flows.
- Comparison of selected final candidate strategies considering restrictions on feasible project implementation timing.

The results of the economic analyses are different in each of these contexts. The analyses of all three contexts are presented for clarity and to document the basis for the Recommended Upcountry District Plan. In short:

- Providing additional raw water storage for the Lower Kula system is cost effective and is recommended in all analysis contexts (provided that sufficient financing can be provided and final design and siting feasibility are verified).
- The cost effectiveness of providing raw water storage capacity a the Kamole WTP depends on several factors:
    - If Wailoa Ditch base flow reductions are less than 30 MGD it would be more cost effective to mitigate base flow reductions by providing a raw water storage reservoir to serve the Kamole WTP than it would be to provide alternative drought period reliable capacity with addition of basal groundwater wells for this purpose.
    - If Wailoa Ditch base flow reductions are more than 30 MGD it would not be cost effective to build a raw water storage reservoir at the Kamole WTP within the planning period time frame.
    - If several basal groundwater wells are added to the Upcountry District system in the interim years before commissioning a Kamole WTP reservoir the cost effectiveness of building the reservoir would be diminished. It would not be beneficial or cost effective to provide duplicative basal groundwater and Kamole reservoir drought period backup capacity[16]



Upcountry District Final Candidate Strategies
50 Year Study Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year; Zero Wailoa Ditch IIFS Impacts.

Initial Comparison of the Final Candidate Strategies

The chart above shows the net present values for the DWS Upcountry District system over the 50 year study period (2005 - 2055) for each of the Final Candidate Strategies. The analyses depicted in this chart assume the low energy cost scenario with energy costs equivalent to $75 per barrel in 2008 escalating a 1% per year above the rate of general inflation throughout the planning period. These analyses assume zero reductions to the base flow of the Wailoa Ditch due to amendments to the interim instream flow standards on East Maui streams.

Variable operating, fixed operating and capital costs are all substantial components of total costs in all strategies. The cost of the DSM (conservation) programs included in each of the strategies is a small component of costs.

The left most column shows the Incremental Basal Well Development strategy. Variable costs associated with power for water pumping are the largest component of costs in this strategy.

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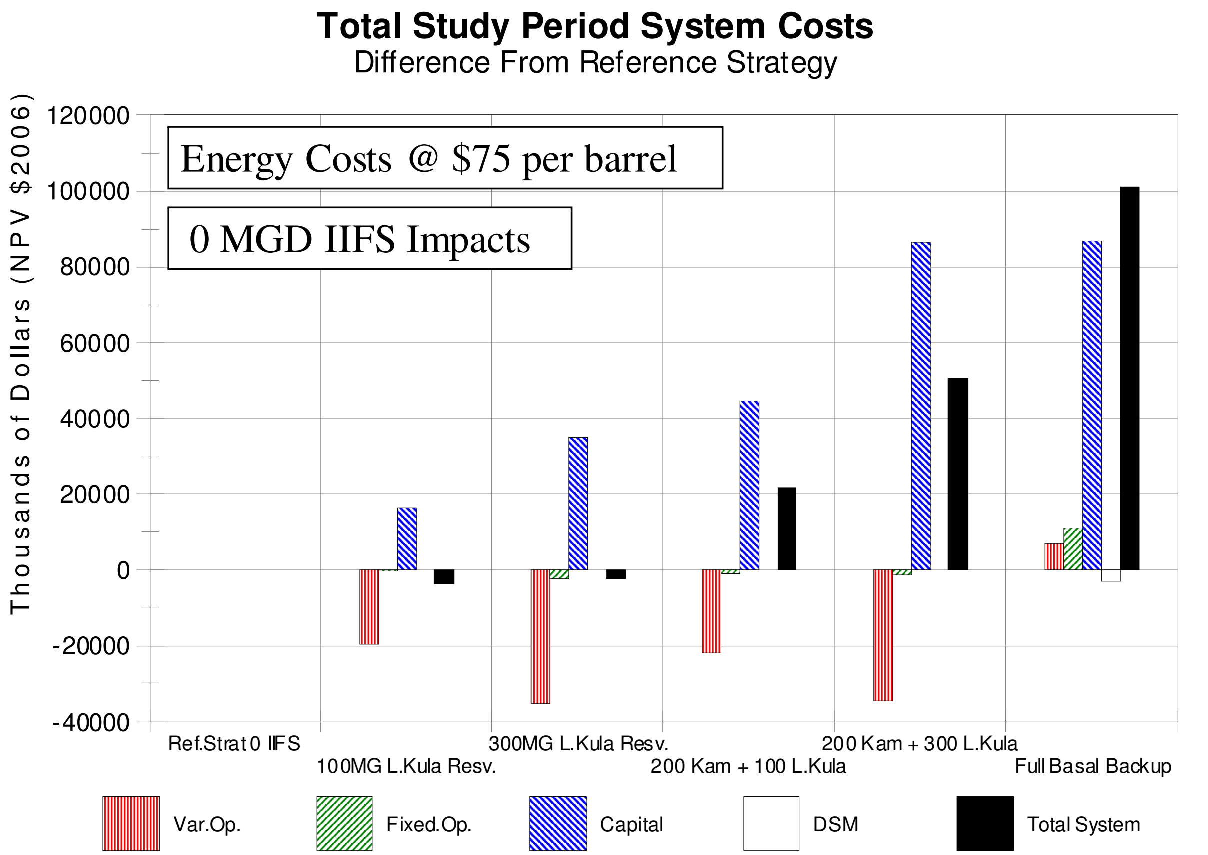
16. Both the basal well and reservoir alternatives are standby resources to provide drought period reliable capacity. Neither alternative would provide substantial water production. A reservoir at the Kamole WTP to mitigate Wailoa Ditch base flow reductions would stand full for this purpose more than 95% of the time. Basal wells to serve this purpose would stand ready but would seldom produce any water.

The differences between the cost components of the strategies is discernible in the chart above but is more clearly seen in the next chart below that shows the same data presented as differences with respect to the Reference Strategy shown at the far left. The economics of the strategies are discussed in the context of the next chart below.



Upcountry District Final Candidate Strategies

50 Year Study Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year; Zero Wailoa Ditch IIFS Impacts.

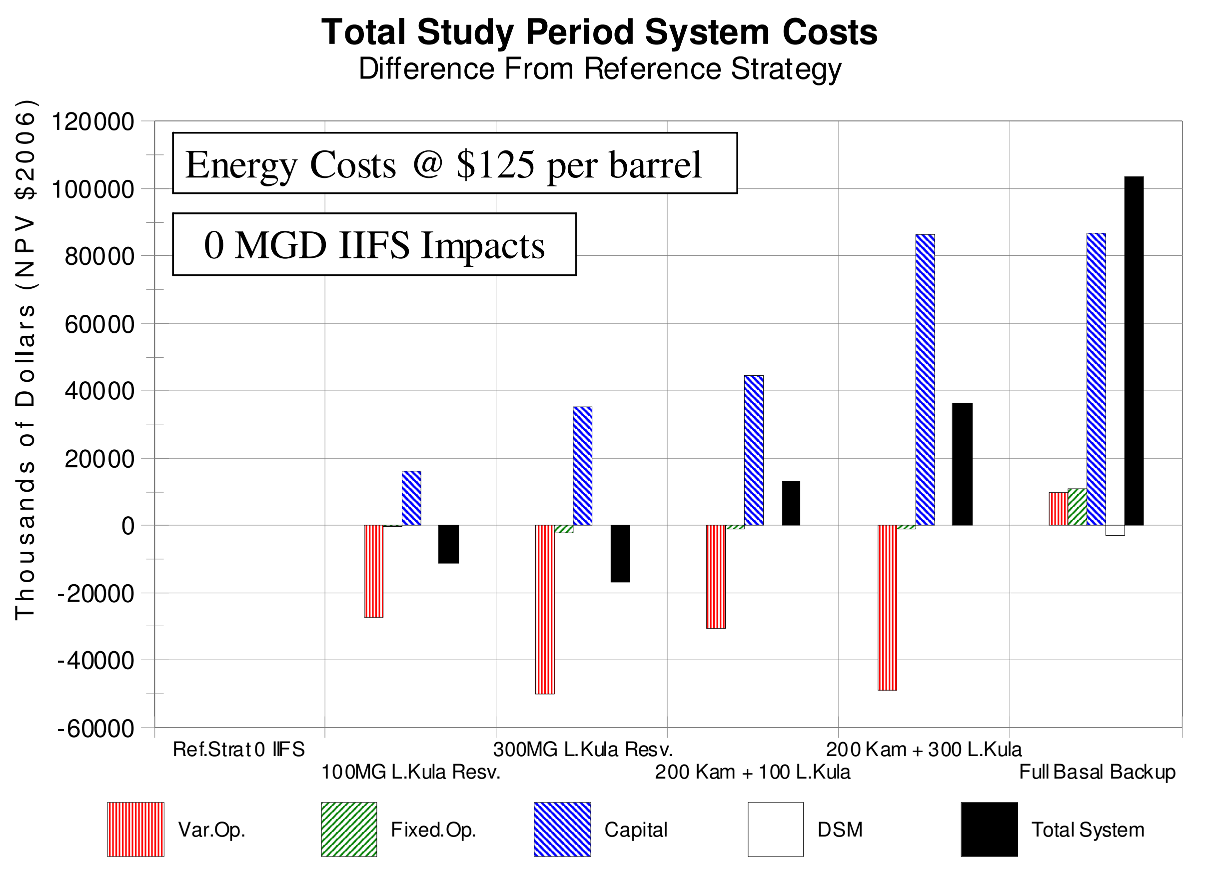
The chart above shows the same data as the previous chart except all costs are portrayed as differences from the Reference Strategy costs at the far left. The costs shown are the total Upcountry District 50 year study period costs, assuming the low energy cost scenario and zero reductions in Wailoa Ditch base flows.

The left most column shows the Incremental Basal Well Development strategy.

The next two columns show strategies that principally feature 100 MG and 300 MG new raw water storage reservoirs on the Lower Kula system. These strategies have substantially higher capital costs associated with reservoir construction and lower variable costs resulting from reduced water pumping requirements. In this analysis, which portrays a low energy cost scenario, the strategy featuring a 100 MG raw water storage reservoir on the Lower Kula system costs about the same as the reference strategy and costs slightly less than 300 MG reservoir strategy.

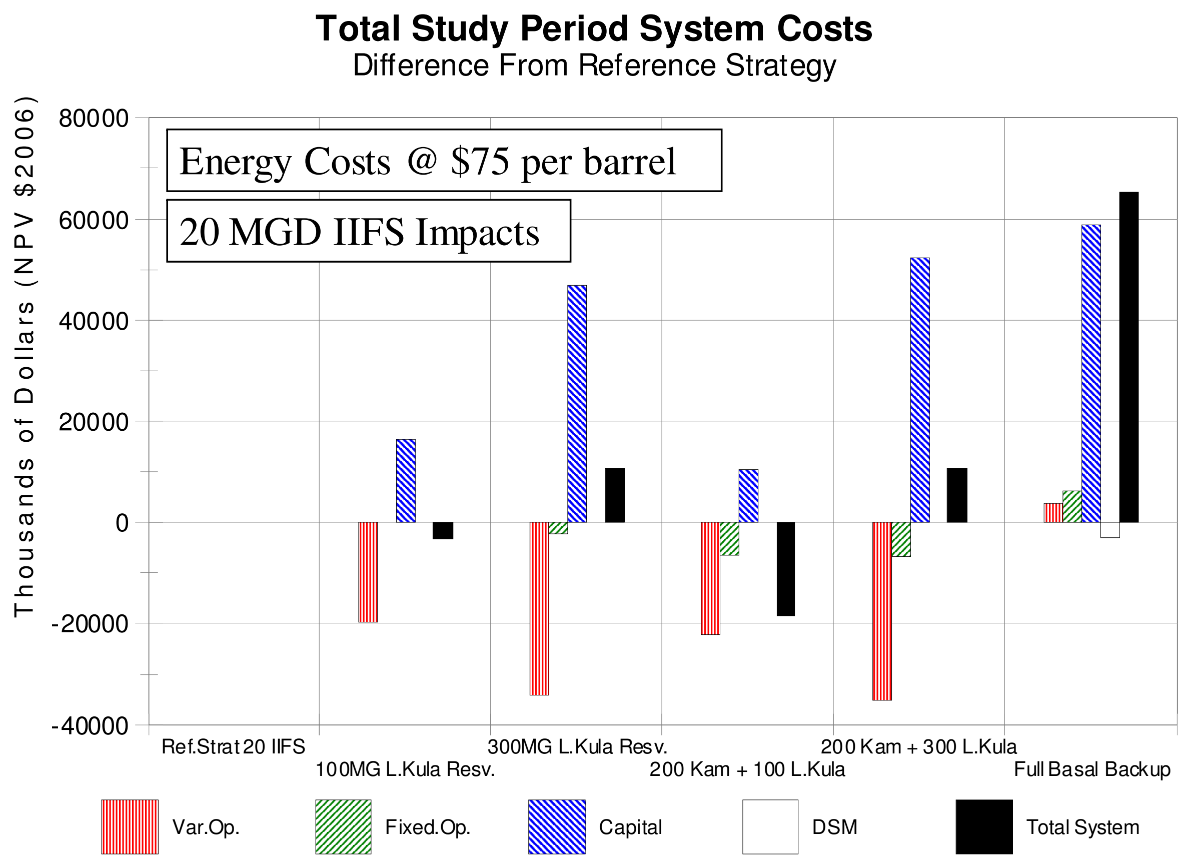
The next two columns show strategies featuring the 100 and 300 MG Lower Kula reservoirs in conjunction with a 200 MG reservoir at the Kamole WTP. In this analysis, which does not assume any reductions in the base flow of the Wailoa Ditch due to amendments in the interim instream flow standards of East Maui streams, the strategies that include the Kamole WTP reservoirs are substantially more expensive than the reference strategy (basal well development) or the strategies that feature reservoirs only on the Lower Kula system.

The right most column shows the costs of the Full Basal Well Backup strategy. The strategy depicted includes sufficient basal groundwater wells to provide reliable water service in extreme drought conditions assuming no water production from the Upper Kula and Lower Kula or Kamole surface water systems.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year; Zero IIFS Impacts.

The chart above shows the same strategies as the previous chart except that the costs for the high energy cost scenario are shown. The raw water storage reservoir options are substantially more cost effective than the reference basal well development strategy if energy costs are higher.

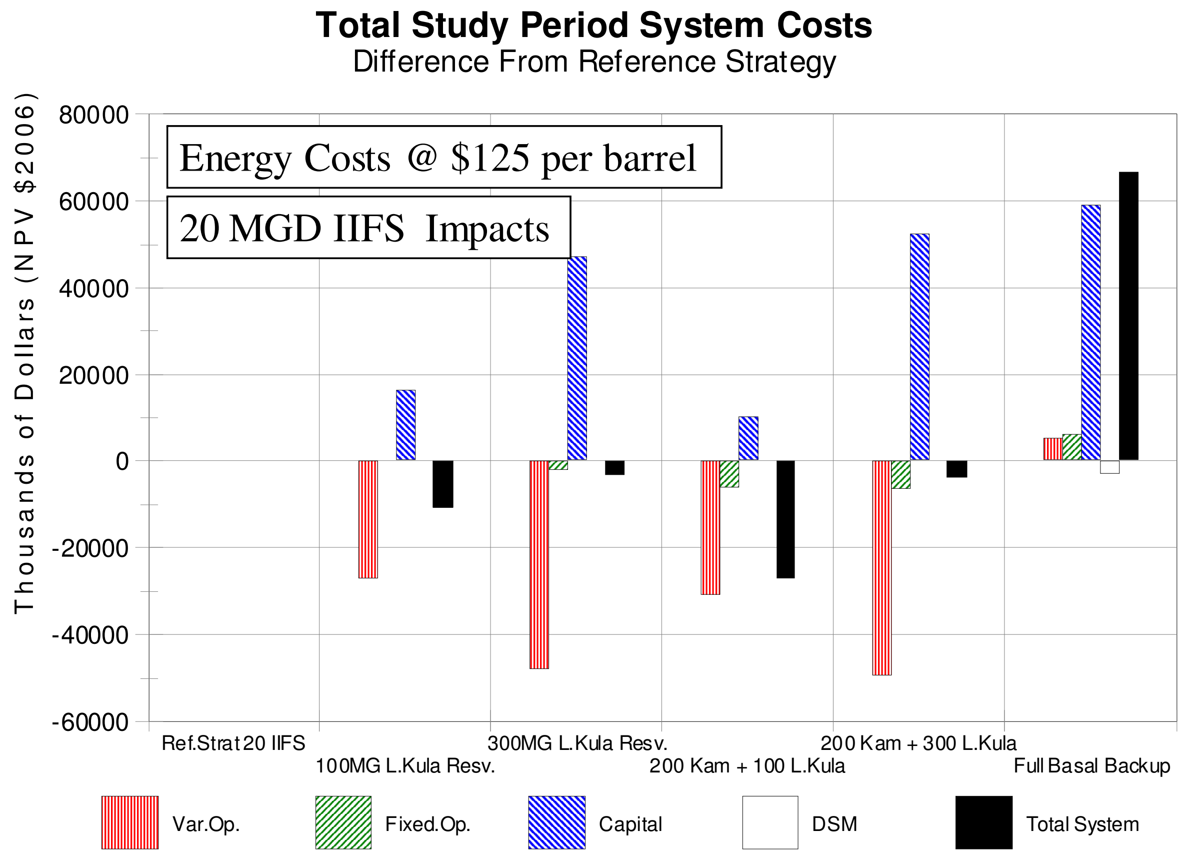


Upcountry District Final Candidate Strategies
50 Year Study Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year; Zero Wailoa Ditch IIFS Impacts.

Consideration of Anticipated Wailoa Ditch Base Flow Reductions

The chart above shows the same strategies except that the impacts of a 20 MGD reduction in Wailoa Ditch base flows are taken into consideration. The low energy cost scenario is depicted.

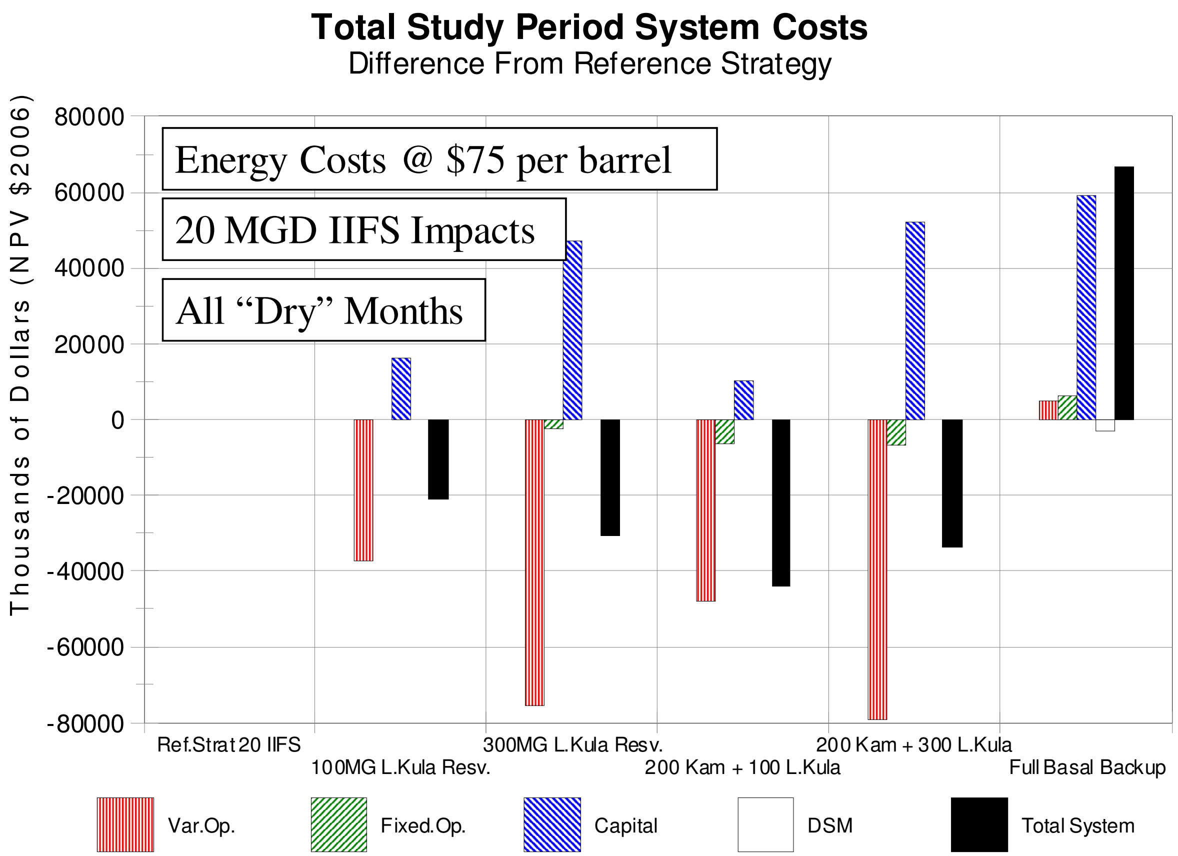
Considering the impacts of a 20 MGD reduction in Wailoa Ditch flows, the benefits of a raw water storage at the Kamole WTP site are clear.



Upcountry District Final Candidate Strategies

50 Year Planning Period NPV Costs; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

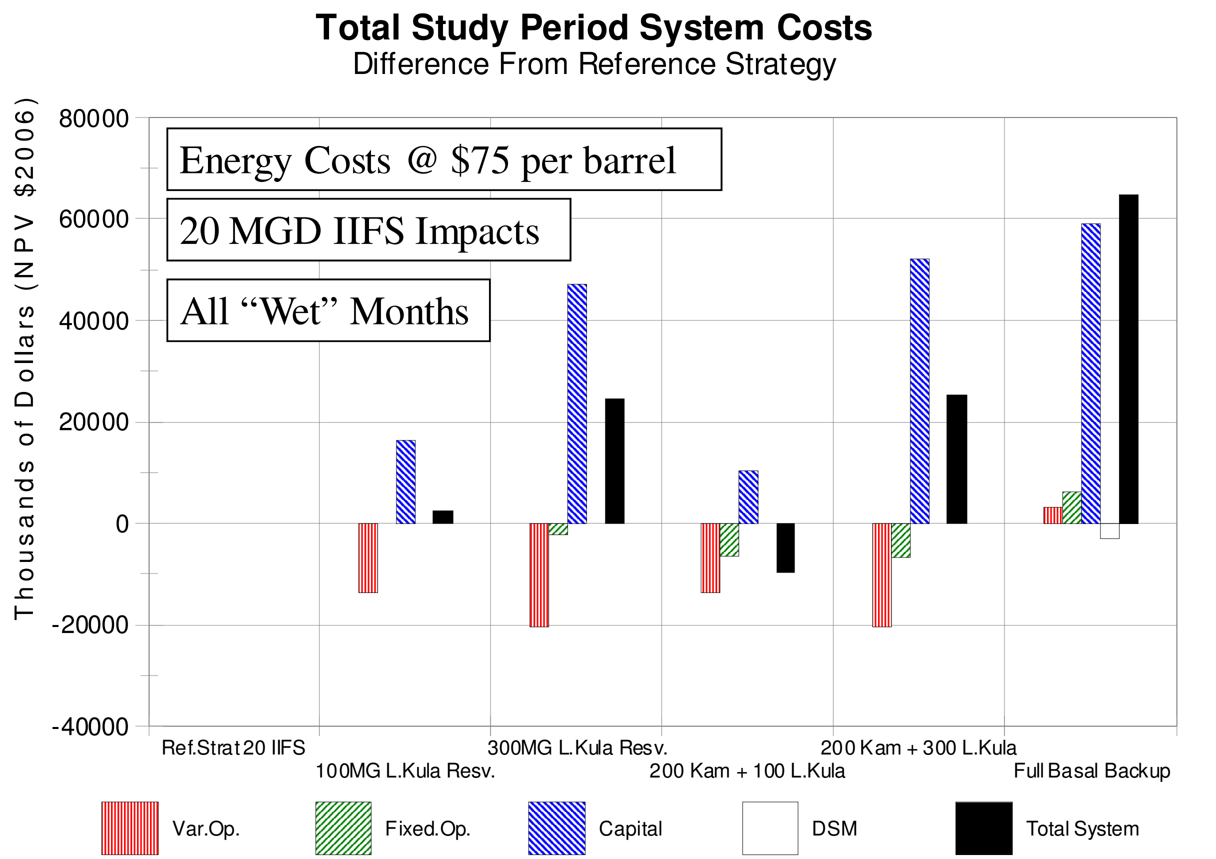
The chart above shows the same set of strategies with the high energy cost scenario, considering the impacts of a 20 MGD reduction in Wailoa Ditch base flows. The most cost effective strategy is the combination of a 200 MG reservoir at the Kamole WTP and a 100 MG reservoir on the Lower Kula system.



Upcountry District Final Candidate Strategies- Dry Months Only
50 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

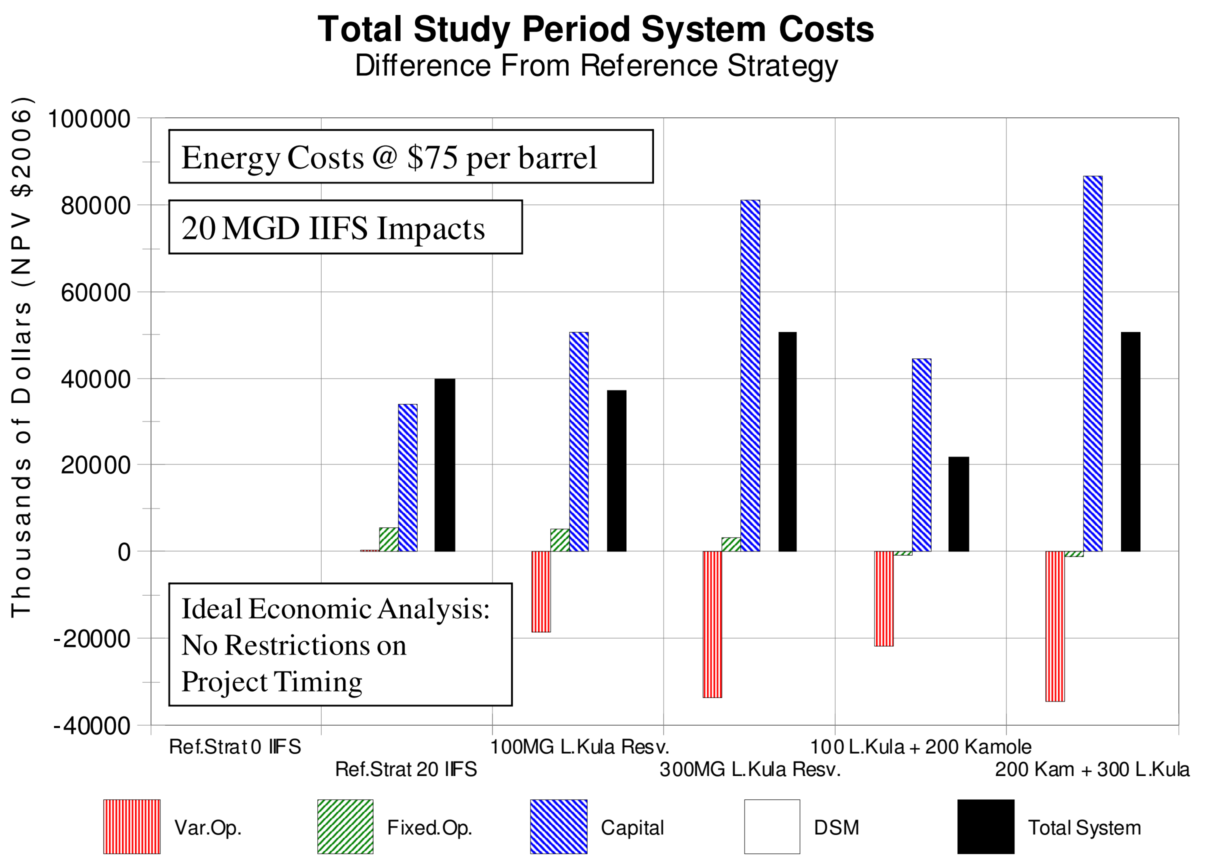
The chart above shows the costs of the strategies for dry months typical of drought conditions or typical of dry summer months. The costs shown are the 50 year study period costs assuming the low energy cost scenario if all months were dry months. This chart can be compared with the chart below which shows a similar analysis for wet period months.

The cost effectiveness of the raw water storage strategies is very apparent in the “dry month” conditions. In the past few years there have been longer dry seasons than in the long term average. If this drier pattern continues, the raw water storage strategies would be commensurately more cost-effective.



Upcountry District Final Candidate Strategies- Wet Months Only
50 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

This chart shows the same strategies for wet period months when less water pumping is required. Note that even in wet conditions additional raw water storage capacity on the Lower Kula system results in lower system operation costs due to reduced pumping requirements.



Upcountry District Final Candidate Strategies

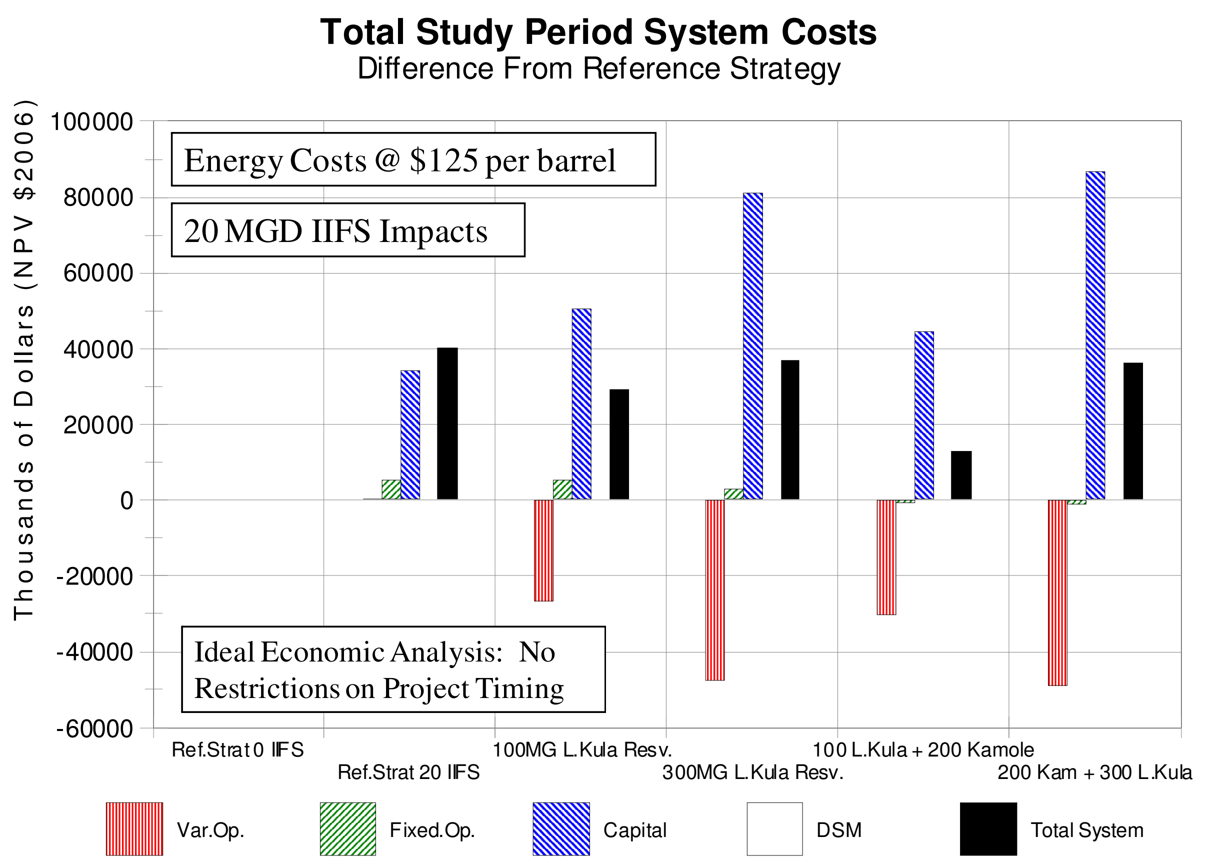
50 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year, .

Consideration of Project Timing Constraints

The chart above shows a comparison of several of the final candidate strategies configured without constraints on feasible resource project timing and phasing. This unconstrained configuration is the same as in the analyses presented in all of the previous charts in this report.

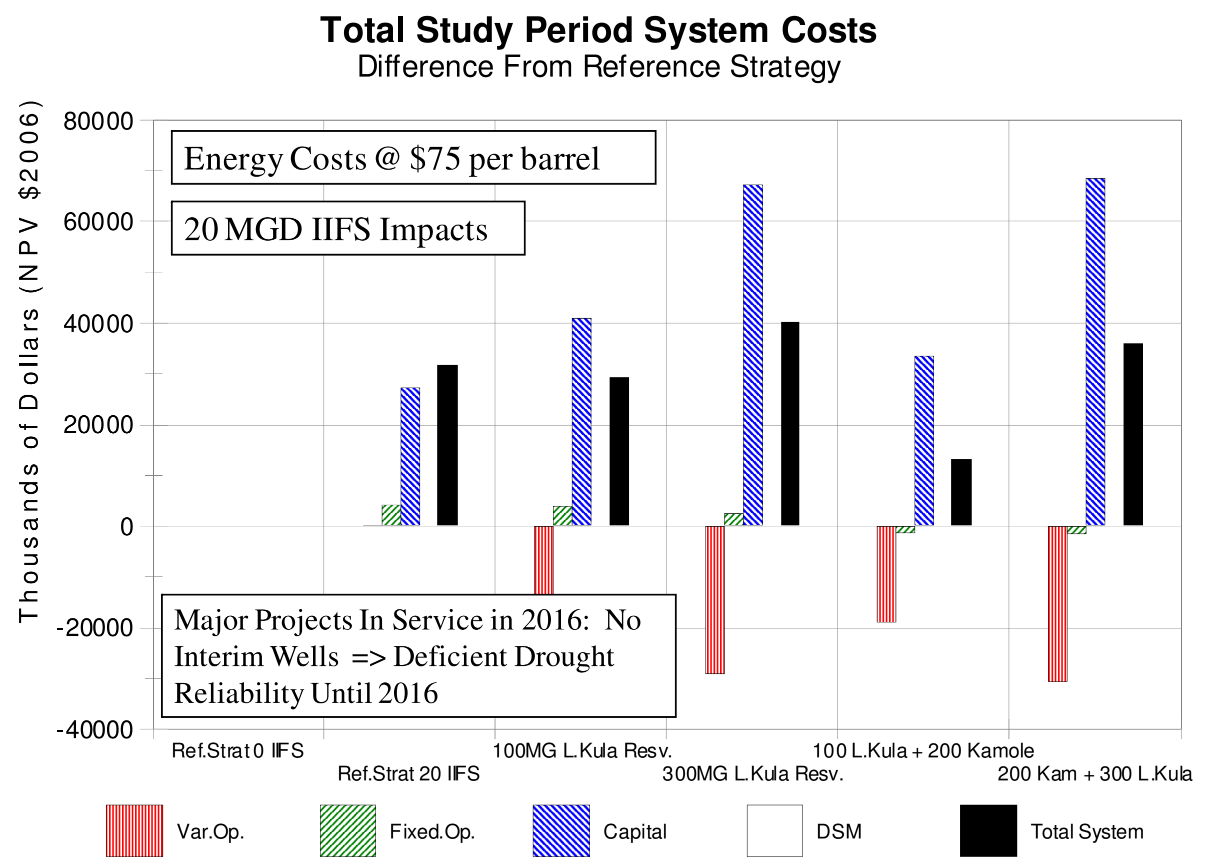
In this chart and in the following charts the strategies are all compared to the basal well development reference strategy optimized for zero Wailoa Ditch base flow reductions. The second column from the left in each chart shows the basal groundwater development reference strategy optimized for a 20 MGD reduction in Wailoa Ditch base flows. Except for the left most column on each chart, all of the strategies depicted in this and the following charts presume a 20 MGD reduction in Wailoa Ditch base flows.

Assuming the low energy cost scenario shown in the chart above, without constraints on project timing, it is cost effective to provide a 200 MGD reservoir at the Kamole WTP in conjunction with a 100 MG reservoir on the Lower Kula system.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

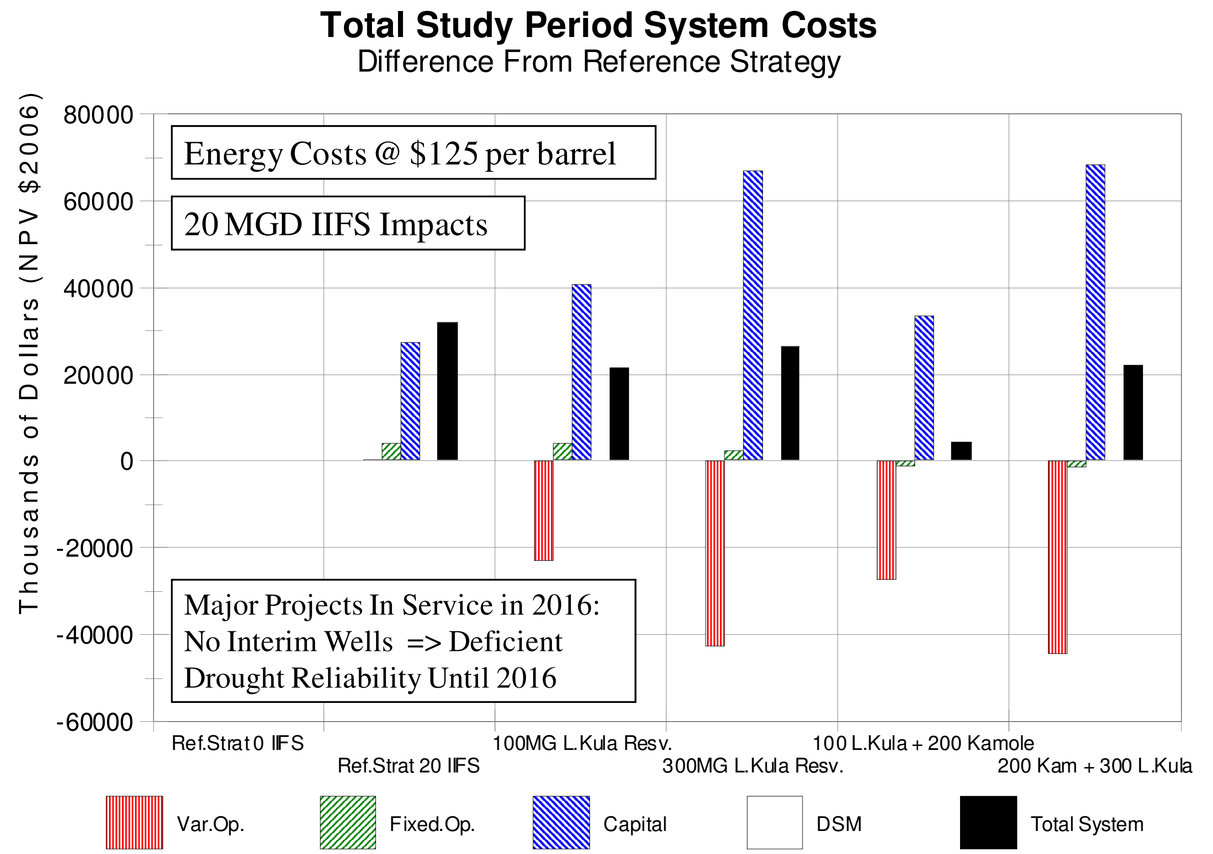
The chart above shows the same strategies and scenario as the previous chart except that the high energy cost scenario is assumed. With higher energy costs all of the reservoir strategies are more cost effective (than with lower energy costs) compared to the basal groundwater strategies.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies except that all additions of reservoirs or major basal well development is deferred until 2016. Under this scenario there would be deficiencies in drought period reliability until the year 2016 when all necessary resources would be put in service. The drought period reliability from the present until the year 2016 in this scenario would be approximately the same as the drought period reliability of the Upcountry District existing system.

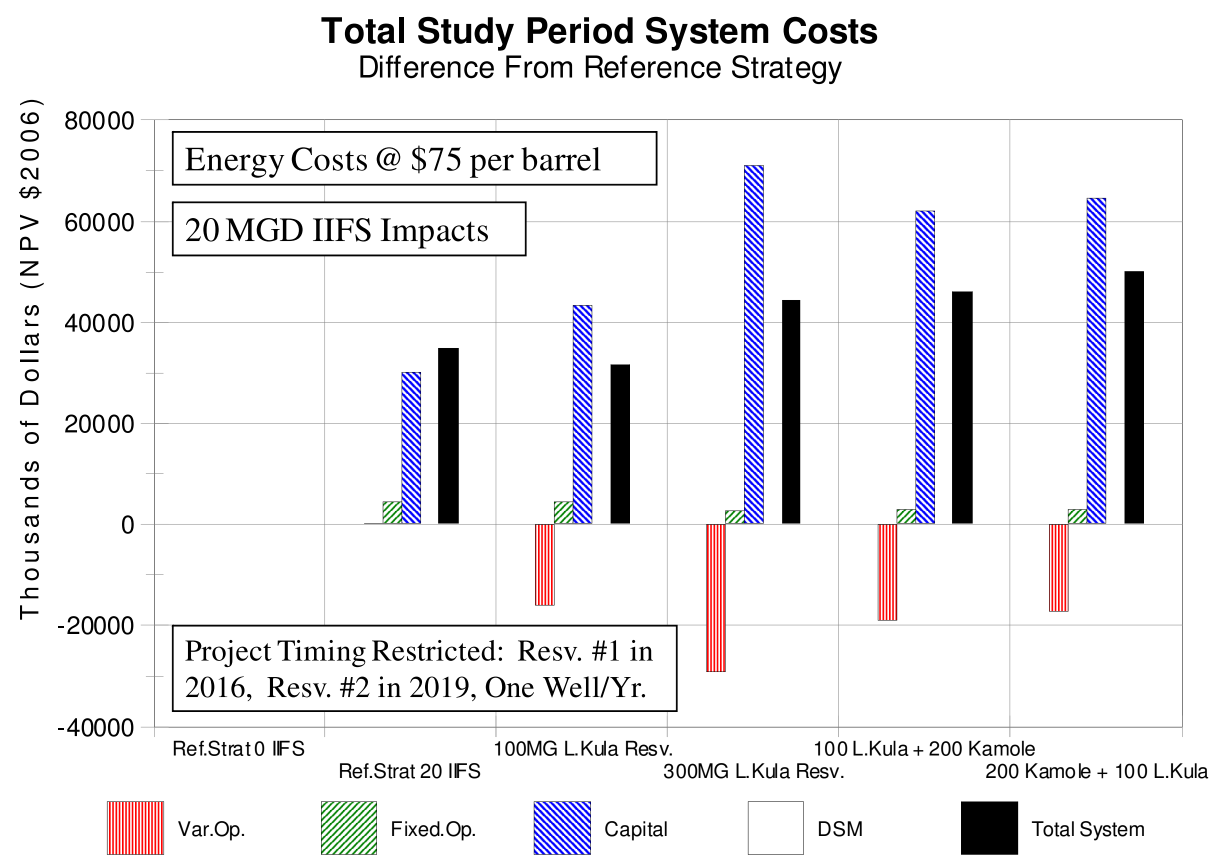
Under these assumptions the results of the comparison of strategies is the same as the previous analysis.



Upcountry District Final Candidate Strategies

50 Year Planning Period NPV Costs; “High” Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies and scenarios except that the high energy cost scenario is assumed. Except for the increased cost effectiveness of the raw water storage reservoir strategies, the results of the comparison of the strategies are not substantially different.

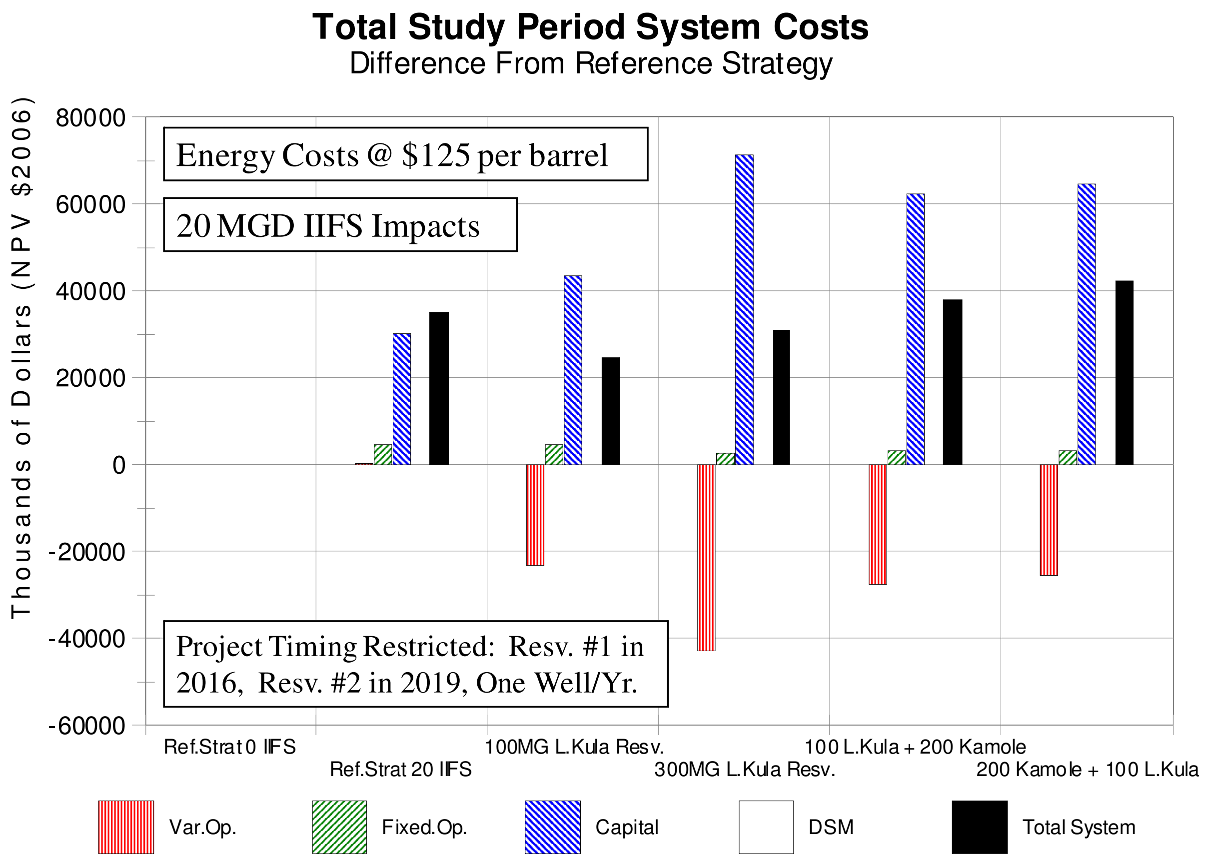


Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows a selection of strategies with the timing of resource implementation constrained. The first reservoir in each strategy is commissioned in the year 2016. In the strategies with a second reservoir, the second reservoir is installed in the year 2019. The timing of the reservoirs is phased to recognize limitations in the feasibility of financing and constructing multiple reservoir construction projects simultaneously. In each strategy, basal groundwater wells are added when needed to provide drought period reliable capacity except that the maximum number of basal groundwater wells added is limited to one per year.

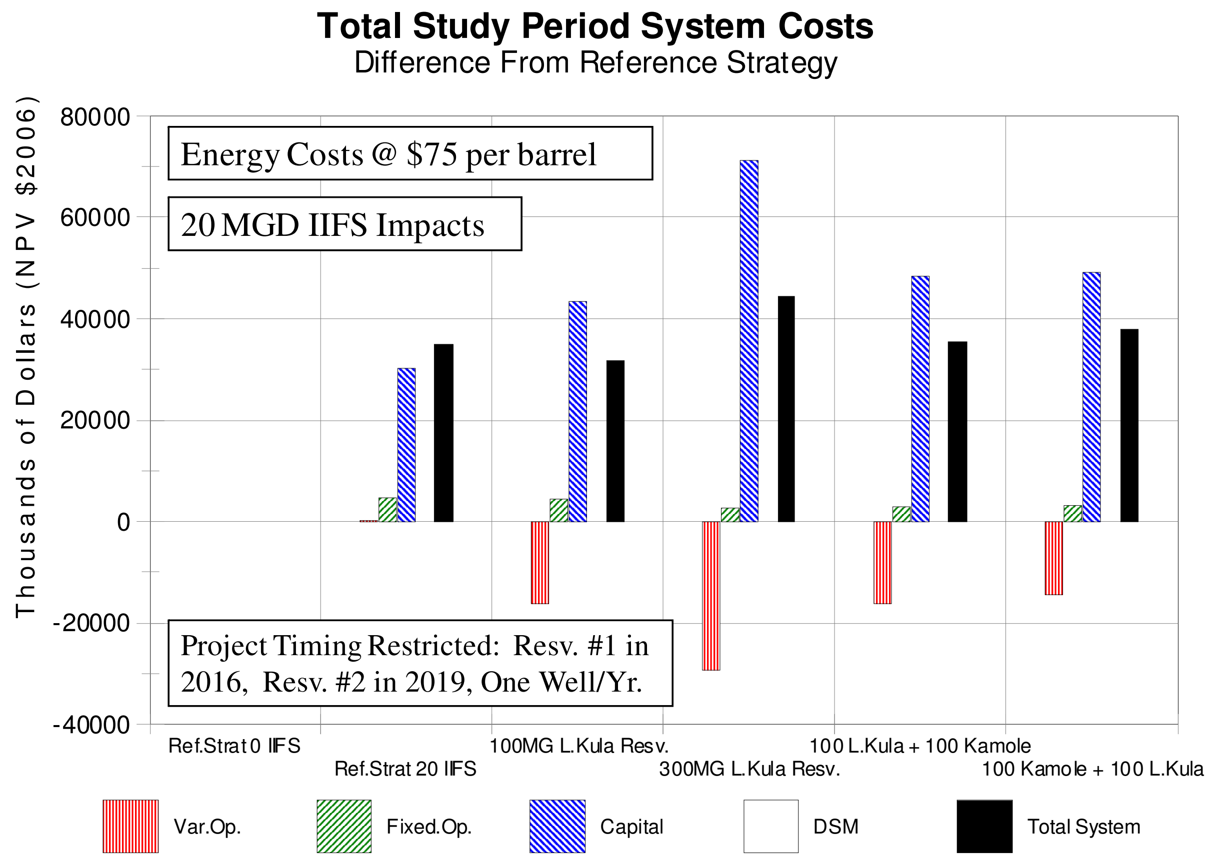
The two columns on the right show strategies that include a 100 MG reservoir on the Lower Kula system and a 200 MG reservoir to serve the Kamole WTP. The difference between these strategies is the sequence that these reservoirs are added. In the second column from the right the 100 MG reservoir on the Lower Kula system is added in 2016 and the Kamole reservoir is added in 2019. In the right most column this sequence is reversed. It is more cost effective to add a reservoir to the Lower Kula system first since a Lower Kula reservoir provides substantially more operational economy than a reservoir at Kamole.

In this analysis, by the time any reservoir is added to the system there are already several basal groundwater wells on the system that can provide drought period reliability to mitigate Wailoa Ditch base flow reductions. Under these circumstances it is not cost effective to add additional drought period reliable capacity by providing a reservoir to serve the Kamole WTP.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

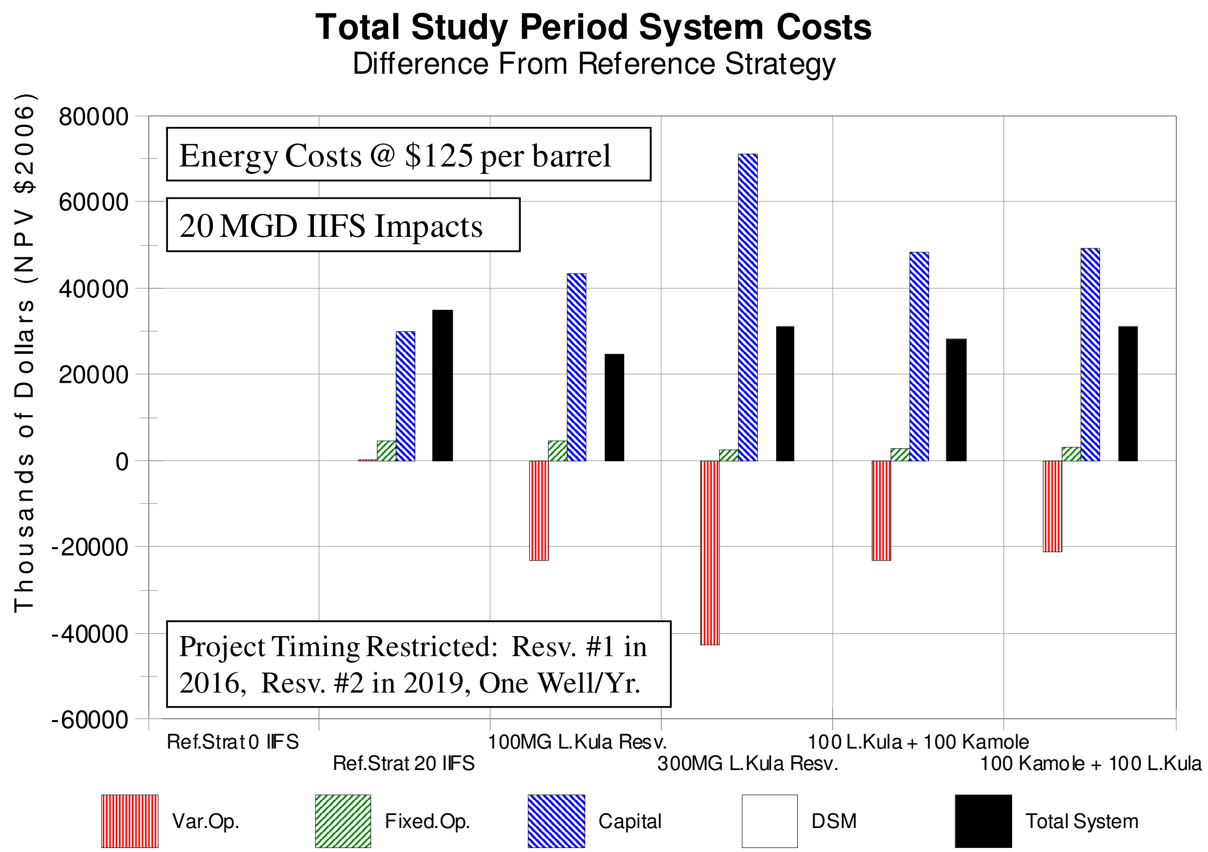
The chart above shows the same strategies and assumptions as the previous chart except that the high energy cost scenario is assumed. Except for the additional operational benefits provided by the reservoir storage strategies with higher energy costs the results of the comparison of the strategies is not substantially changed.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; “Low” Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

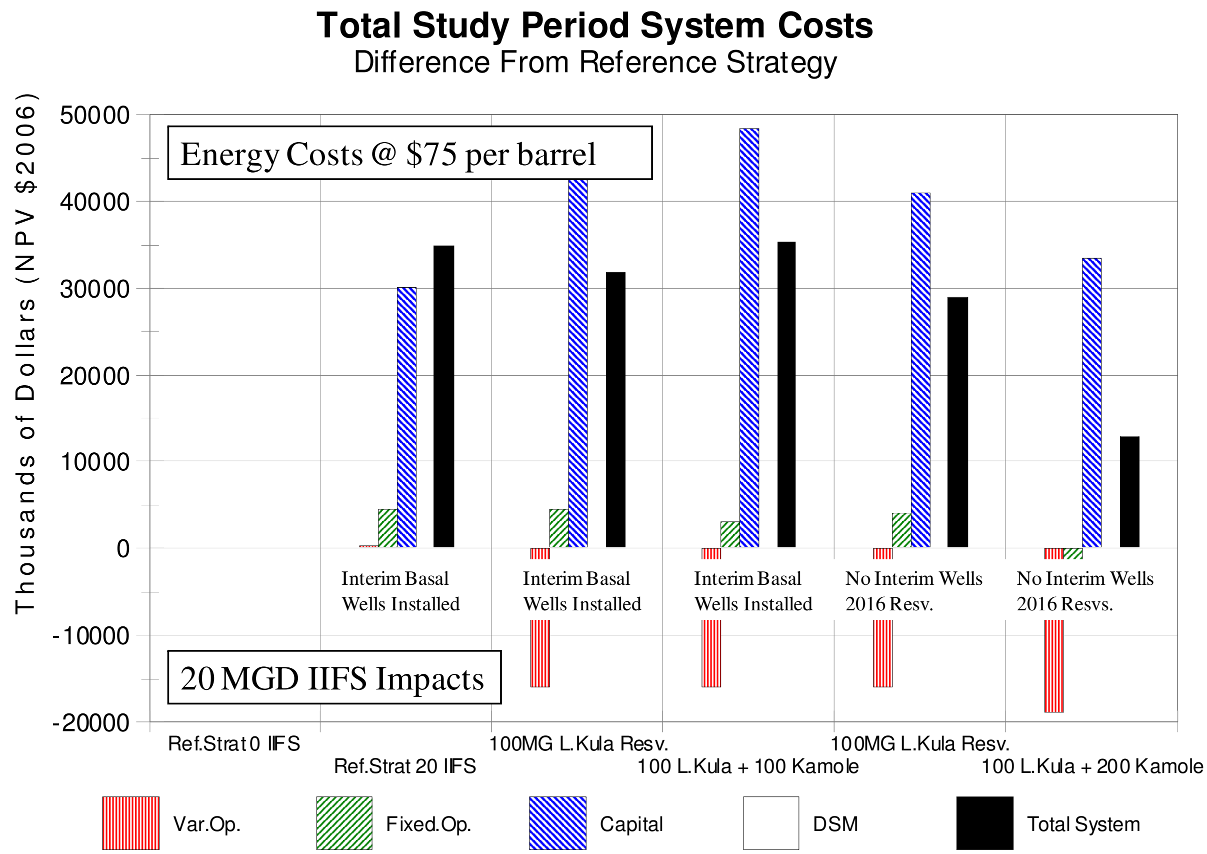
The chart above shows the same assumptions as the previous chart for the low energy cost scenario. The strategies depicted are the same except for the two columns on the right. These columns depict strategies with 100 MG reservoir additions at the Kamole WTP rather than the 200 MG additions shown in the prior two charts. The strategy shown in the second column from the right includes a 100 MG reservoir on the Lower Kula system added in 2016 and a 100 MG reservoir serving the Kamole WTP added in 2019. In the right most column this sequence is reversed.

Under these assumptions the strategies depicted in the chart above are all within a relatively close range of total system costs for the 50 year study period. The differences in costs between these strategies is within the range of uncertainties regarding assumptions regarding project capital costs.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies and assumptions as the previous chart except that the high energy cost scenarios is assumed. All of the strategies include a Lower Kula reservoir that provides additional economy in the high energy cost scenario when compared to the basal groundwater development strategy.



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "Low" Energy Price Scenario w $75/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above compares the costs of several strategies with alternate assumptions regarding the installation of basal groundwater wells in the interim period before storage reservoir construction is completed. The left most column shows the same reference strategy as in the previous analyses (basal well development assuming zero IIFS impacts) for reference. The next three columns show three of the same strategies as depicted on the previous chart. These strategies presume that a reservoir would be installed in 2016, a second reservoir (if one is included) would be installed in 2019 and that basal wells would be added at a rate of one well per year in the interim period as necessary. The two columns on the right show strategies with reservoirs added in the year 2016 but without any basal wells added in the interim period.

All of the strategies shown in the chart above meet the drought period reliability criteria starting in the year 2016. None of the strategies shown above meets the drought period reliability criteria in the years up until 2016. The strategies that do not add interim wells maintain approximately the same level of system reliability as the current Upcountry system until the year 2016. The strategies that add basal wells in the interim period provide incrementally increasing reliability until the year 2016.

This analysis indicates that delaying the installation of basal wells until a reservoir can be added is less expensive than adding wells in an interim period but provides less interim drought period reliability. This is shown by the fact that the strategy featuring a 100 MG reservoir on the Lower

Kula system (second column from the right) that defers addition of basal wells until a reservoir is installed is less expensive than a strategy that adds wells incrementally in the interim period (third column from the left). The 100 MG Lower Kula reservoir strategy requires five basal wells in addition to the reservoir in either case. The overall difference in total system costs in this comparison is relatively small, representing only the deferred costs of basal well installation. If a 100 MG Lower Kula reservoir strategy is selected, construction of interim basal wells to provide interim drought period reliability would not cause substantial long term increases in total system costs.

The most cost effective strategy examined is depicted in the right-most column. This strategy includes a 200 MG storage reservoir for the Kamole WTP in addition to a 100 MG reservoir on the Lower Kula system but does not ultimately require additional basal wells. If basal wells are added in the interim period before the reservoirs are commissioned, as depicted in the strategy shown in the third column from the right, the strategy is no longer the most cost effective.[17] In this case deferring mitigation of drought period reliability until reservoir construction could be completed is substantially less expensive than installation of interim basal wells.

The resource installation dates and statistics describing drought period reliability are shown on the table on the following page. Note that the rate impacts shown on the table reflect long term levelized rates. Short term rate impacts could be substantially higher.

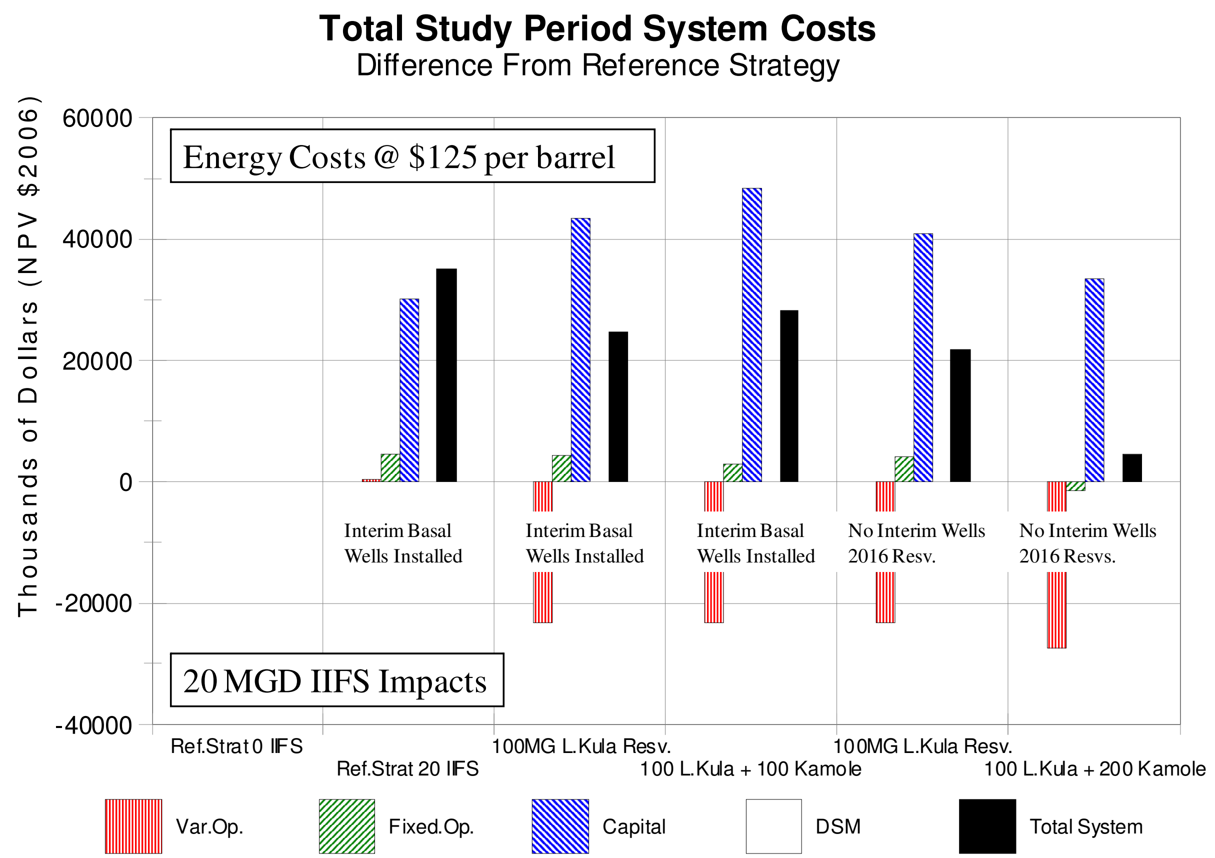
17. Note that these strategies are not identical. The result is the same and the comparison is even more extreme with identical reservoir configurations. This comparison shows that even a larger reservoir installation at Kamole is made cost effective if the basal wells that otherwise would be needed could be avoided and mitigation of reliability improvements deferred until both reservoirs could be installed.

Comparison of Upcountry Candidate Strategies

Ref. Strategy and Strategies With 20 MGD Reduced Wailoa Ditch Base Flow w Low Energy Cost Scenario

System:	DWS Upcountry System	DWS Upcountry System	DWS Upcountry System	DWS Upcountry System	DWS Upcountry System	DWS Upcountry System
Strategy Name	**Ref.Strat 0 IIFS**	**Ref.Strat 20 IIFS**	**100MG L.Kula Resv.**	**100 L.Kula + 100 Kamole**	**100MG L.Kula Resv.**	**100 L.Kula + 200 Kamole**
Description	DSM Indoor DtD 10Yr.	DSM Indoor DtD 10Yr.	20MG IIFS Impact	20MG IIFS Impact	20MG IIFS Impact	20MG IIFS Impact
Demand Projection	Medium-High Case	Medium-High Case	Medium-High Case	Medium-High Case	Medium-High Case	Medium-High Case
Demand Proj.Source	WUDPv31 w Waitlist Profile	WUDPv31 w Waitlist Profile	WUDPv31 w Waitlist Profile	WUDPv31 w Waitlist Profile	WUDPv31 w Waitlist Profile	WUDPv31 w Waitlist Profile
Drought/Summer Fraction	25%	25%	25%	25%	25%	25%
Notes:	IIFS Impact = 0	20 MGD Red. Base Flow	20 MGD Red. Base Flow	20 MGD Red. Base Flow	20 MGD Red. Base Flow	20 MGD Red. Base Flow
		DWS 50% w 12MGD Balance	DWS 50% w 12MGD Balance	DWS 50% w 12MGD Balance	DWS 50% w 12MGD Balance	DWS 50% w 12MGD Balance
Var.Op.Esc.Rate	5.30%	5.30%	5.30%	5.30%	5.30%	5.30%
Fix.Op.Esc.Rate	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Cap.Cost.Esc.Rate	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Discount Rate	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
Cost of Capital	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
Unserved Demand kgal	0	0	0	0	0	0
Cap.Shortfall 2006-30 MGD-Yrs.	-8.685	-51.338	-50.142	-52.322	-57.054	-59.655
Cap.Shortfall 2007-30 MGD-Yrs.	-0.036	-17.461	-17.265	-19.445	-25.905	-28.506
Cap.Shortfall 2008-30 MGD-Yrs.	-0.036	-1.967	-1.770	-3.950	-5.226	-5.737
Net Present Value Costs	**$M NPV 2006**	**$M NPV 2006**	**$M NPV 2006**	**$M NPV 2006**	**$M NPV 2006**	**$M NPV 2006**
25 Year Planning Period Costs:						
Variable Operation Cost NPV	75,352	75,524	65,615	65,615	65,615	63,917
Fixed Operation Cost NPV	59,938	62,421	62,330	61,594	61,926	59,076
Capital Cost NPV	58,865	79,949	87,942	90,457	84,884	80,053
DSM Program Cost	3,037	3,037	3,037	3,037	3,037	3,037
Total System Cost NPV	197,192	220,930	218,923	220,702	215,462	206,083
50 Year Study Period Costs:						
Variable Operation Cost NPV	151,657	152,016	128,404	128,404	128,404	124,238
Fixed Operation Cost NPV	90,922	95,494	95,439	93,963	95,034	89,483
Capital Cost NPV	78,135	108,278	121,555	126,581	119,105	111,636
Total System Cost NPV	324,520	359,594	349,205	352,754	346,349	329,163
25 Year Planning Period Rate Impacts:						
Avg. Annual DWS Rate Increase	4.61%	5.40%	5.25%	5.39%	5.64%	5.34%
Levelized Unit Cost ($/kgal)	$5.420	$6.082	$6.026	$6.076	$5.930	$5.668

Resource Addition Sequence:	Ref.Strat 0 IIFS		Ref.Strat 20 IIFS		100MG L.Kula Resv.		100 L.Kula + 100 Kamole		100MG L.Kula Resv.		100 L.Kula + 200 Kamole	
	Ph 10 Boost Add.	2009	Ph 10 Boost Add.	2009	Ph 10 Boost Add.	2009	Ph 10 Boost Add.	2009	Ph 10 Boost Add.	2009	Ph 10 Boost Add.	2009
	Phase 6 Boost Add.	2009	Phase 6 Boost Add.	2009	Phase 6 Boost Add.	2009	Phase 6 Boost Add.	2009	Phase 6 Boost Add.	2009	Phase 6 Boost Add.	2009
	DSM Indoor 45% 10Yr	2009	DSM Indoor 45% 10Yr	2009	DSM Indoor 45% 10Yr	2009	DSM Indoor 45% 10Yr	2009	DSM Indoor 45% 10Yr	2009	DSM Indoor 45% 10Yr	2009
	Well 1300ft Kokomo	2011	Well 1300ft Kokomo	2011	Well 1300ft Kokomo	2011	Well 1300ft Kokomo	2011	Well 1300ft Kokomo	2011	100MG Reservoir	2016
	Well 1600' (Mak)	2011	Well 1600' (Mak)	2011	Well 1600' (Mak)	2011	Well 1600' (Mak)	2011	5 Wells 1600' (Mak)	2016	200MG Kamole Res	2016
	Ph 10 Boost Add#2	2012	Ph 10 Boost Add#2	2012	Well 1600' (Mak)	2012	Well 1600' (Mak)	2012	100MG Reservoir	2016	Phase 6 #2 Boost Add.	2016
	Phase 6 #2 Boost Add.	2016	Well 1600' (Mak)	2012	Well 1600' (Mak)	2013	Well 1600' (Mak)	2013	Phase 6 #2 Boost Add.	2016	Ph 10 Boost Add#2	2027
	Well 1600' (Mak)	2017	Well 1600' (Mak)	2013	Well 1600' (Mak)	2014	Well 1600' (Mak)	2014	Ph 10 Boost Add#2	2019		
	Well 1600' (Mak)	2024	Well 1600' (Mak)	2014	Well 1600' (Mak)	2015	Well 1600' (Mak)	2015	Well 1600' (Mak)	2019		
			Well 1600' (Mak)	2015	Phase 6 #2 Boost Add.	2016	Phase 6 #2 Boost Add.	2016	Well 1600' (Mak)	2025		
			3 Wells 1600' (Mak)	2016	Well 1600' (Mak)	2016	100MG L.Kula Res.	2016				
			6 Wells 1600' (Mak)	2016	100MG Reservoir	2016	100MG Kamole Res	2019				
			Well 1600' (Mak)	2023	Well 1600' (Mak)	2019	Ph 10 Boost Add#2	2027				
					Well 1600' (Mak)	2025						
					Ph 10 Boost Add#2	2027						



Upcountry District Final Candidate Strategies
50 Year Planning Period NPV Costs; "High" Energy Price Scenario w $125/bbl 2008 Equiv. Electrical Power Costs Escalated at 1.0% (Real) per Year.

The chart above shows the same strategies and assumptions as the previous chart except that the high energy cost scenario is assumed.

SUMMARY

In all of the analyses comparing the final candidate strategies the most cost effective strategy includes a raw water storage reservoir on the Lower Kula system. In most cases a 100 MG reservoir is more cost effective than a 300 MG reservoir but the differences in total costs are well within the range of uncertainty regarding the capital costs for these reservoirs. A larger reservoir would be more cost effective if construction costs are lower than estimated or if any substantial federal or state financial assistance can be provided.

The cost effectiveness of a reservoir at the Kamole WTP depends on the magnitude of reductions in Wailoa Ditch flows and whether a substantial number of wells would be added to the Upcountry District system in the interim period before a reservoir could be commissioned. If Wailoa Ditch base flows are greater than 30 MGD[18] or if substantial basal well capacity is added to the system it would not be cost effective to provide reservoir capacity to serve the Kamole WTP.

18. The cost effectiveness of a reservoir to serve the Kamole WTP under various assumed reductions in Wailoa Ditch base flows is provided in the previous section "B. Expansion of Raw Water Storage Capacity".

Comparison of the Merits of the Final Candidate Strategies

The merits of the final candidate strategies can be assessed using the Planning Objective and Attributes Matrix and consideration of the economic analyses described above. The recommendations provided in the following section are based on consideration of the merits of the final candidate strategies with respect to each of the planning objectives identified in the Upcountry District WUDP process.

Recommended Upcountry District Plan

The Upcountry District is at a threshold in terms of the economics of water supply to meet new water demands. The Upper Kula and Lower Kula surface water systems are the major source of inexpensive water for this region. The reliable capacity of these sources is finite and, in the drier summer months and during drought conditions, is already at practical limits. Additional reservoir capacity can provide only limited additional reliable drought period capacity. New growth in water demand on the Upcountry system will have to be met by substantially more expensive resources.[19]

The limits on the amount of economical water available in the Upcountry District result in several important water allocation policy issues that must be resolved. Surface water must be allocated between municipal uses, agricultural uses and the need for restoration of water to East Maui streams. In the near future the operation protocols and water pricing policies for the Upper Kula non-potable water line will have to be resolved.[20] It is also clear that the availability of water currently diverted from East Maui streams for municipal and agricultural purposes will be reduced as amendments are made to the incumbent Interim Instream Flow Standards for these streams. The magnitude of these reductions has not been determined but it is clear that mitigating actions will be necessary in order to maintain the existing level of drought period reliable capacity provided by the East Maui Irrigation ditch system.

Meanwhile, there is a pressing need for additional water production capacity. There is an existing backlog of water demand on the Upcountry District system with a substantial waiting list for new water meters. There is frustration regarding recurrent needs to conserve water during dry periods when water is most needed for irrigation purposes.

There are several policy determinations that need to be addressed, either implicitly or explicitly in deciding and implementing a recommended plan. These determinations can be informed by analysis but are not answered resolutely by analyses:

- How will providing drought period reliability be balanced with providing the most economic water services.
- How will agricultural water needs be balanced with municipal water availability and pricing?
- Will the County continue to support the amendment of East Maui stream interim instream flow standards in light of the resulting costs to mitigate impacts on the drought period reliability of the Upcountry system?
- Are the limits to Upcountry District availability for new meters to be determined primarily by drought period reliability criteria or by operational economics? This affects both policies regarding the issuance of new meters and how the system is operated to maintain drought reliability.
- Will efficient use of water be promoted by expenditures on conservation programs, by mandates or by a combination of both?

19. Depending on location of water use, marginal production costs for new water demand in drier summer months is up to ten times as expensive as existing average water production costs. The capital costs to provide new water sources for new water services is several times higher than existing the existing system development fees intended to cover these costs.

20. There is a stark divergence of thought amongst the various implementing and affected agencies and stakeholders regarding how water feeding into and out of the agricultural water line will be priced, managed, controlled and allocated.

A recommended Upcountry District plan is outlined below to serve as a starting point for review and discussion for the Upcountry District section of the Maui County Water Use and Development Plan. The general terms of the recommended strategy are described, followed by some specific recommendations consistent with implementation of the strategy.

The recommended strategy attempts to address the planning objectives derived from comments by the Upcountry District Water Advisory Committee. The strategy consists of several components:

- Department of Water Supply actions to provide water needs for its customers
  - Conservation programs to reduce water production requirements
  - New sources of water supply
  - Regulations and rate designs to promote responsible use of water
- Programs to protect the county's aquifers, watersheds and streams
- Priorities and policies regarding water use and allocation

The recommended Upcountry District Plan is outlined below:

Short Term Resources

- ACQUIRE NEW WELLS INSTALLED BY NON-DWS DEVELOPERS AS APPROPRIATE: New wells that comply with DWS standards and would provide resources that will be of long term value to the DWS Upcountry District should be acquired provided that contractual terms are beneficial to the DWS and its customers.
- PROVIDE BOOSTER PUMP STATION EQUIPMENT REDUNDANCY: Provide third trains of motors and pumps to the Phase 6 and Phase 10 booster pumps to provide sufficient backup reliability to operate two pumps at each booster station continuously with sufficient backup capacity. In the alternative, provide backup replacement equipment on-island to allow immediate replacement of failed equipment.
- CONTINUE AND ACCELERATE LEAK DETECTION AND REPAIR PROGRAM
  - Provide additional budget, staff and equipment to accelerate leak detection and repair for all DWS systems.
- REFINE SYSTEM OPERATING PROTOCOLS TO INCREASE PRODUCTIVE USE OF EXISTING RESERVOIRS
  - Refine Upcountry District system reliability standards
  - Examine and determine system operational constraints and identify explicit appropriate protocols for reservoir management
  - Determine what system modifications and measures are necessary to increase system reliability and/or productive use of surface water capacity
- EXPLORE DEMAND RESPONSE OPTIONS Demand response options are measures that can be implemented quickly during periods of restricted water availability or in response to water supply system disruptions. In order for these options to be effective, protocols and authorities need to be established in advance of the need for demand response measures.
  - Landscape irrigation scheduling restrictions
  - Monitoring and enforcement of waste prohibitions
  - End-use restrictions (on pavement cleaning / watering, automobile washing, dust control with potable water and other discretionary uses of water)

- CONTINUE INVESTIGATION OF SURFACE WATER TREATMENT DISINFECTION BYPRODUCT REDUCTION MEASURES

Long Term Resources

In previous sections of this report several final resource strategies were examined that posed alternative approaches to providing new water supply for the DWS. The recommended strategy recognizes that there is substantial uncertainty regarding the feasibility, costs and timing of the availability of some of the final resource strategies.

Discussion:

- Additional raw water storage reservoir capacity for the Lower Kula system would be cost effective and would provide long term benefits in terms of reduced electrical power consumption and operating costs.
  - Optimum added reservoir capacity from an economic and system operation standpoint would be between 100 to 300 million gallons.
  - Permitting and construction of a 300 million gallon reservoir east of the existing reservoir may not be practical due to environmental concerns at the candidate sites east of the existing Piiholo reservoir.
    - Candidate reservoir sites for a 300 MG reservoir east of the existing reservoir are located where roads through protected subzones with identified endangered species would be required. A Habitat Conservation Plan and Incidental Take License(s) would be required which could add substantial costs to the project
  - A reservoir of at least 100 MG may be feasible near the existing Piiholo reservoir outside of environmentally sensitive areas.
  - Budgeting for the large initial capital expenditures for reservoir construction has not been determined or committed.
- New raw water storage capacity to serve the Kamole WTP would cost less than addition of basal wells as a means to mitigate the expected reductions in Wailoa Ditch base flows resulting from implementation of amendments to the interim instream flow standards on East Maui streams. However, if a substantial number of basal wells would be added to the Upcountry system prior to commissioning a Kamole WTP reservoir, the cost effectiveness of the installing the reservoir would be diminished.
  - A 100 MG reservoir would mitigate a 20 MGD reduction in Wailoa Ditch base flows.
  - A 200 MG reservoir would mitigate a 30 MGD reduction in Wailoa Ditch base flows.
  - With reductions in base flows exceeding 30 MGD it would be more cost effective to provide drought period reliable capacity by additional basal wells than adding reservoir capacity for the Kamole WTP.
  - Budgeting for the large initial capital expenditures for reservoir construction has not been determined or committed.
- Basal groundwater wells are being drilled and developed by non-DWS entities. These wells are being offered to the DWS in trade for source credits and water entitlements or are being offered to meet subdivision requirements to identify a source of water to serve new services.
  - The addition of basal well capacity does not provide all of the infrastructure necessary to provide an economical source of water.

        - Basal wells function as backup resources and do not provide economical water production capability.
        - Water from basal wells also requires installation and operation of booster pump capacity to deliver water to the location of water demands.
    - The long term water quality and long term productivity of new wells is not possible to determine reliably until wells are drilled and tested. The productivity and water quality of some wells are proving to be substantially different from others even in relatively close proximity.
- Improvements to the intake structure of the Kamole WTP is cost effective compared to drilling new basal wells to provide incremental drought period reliable capacity.
    - The ability of these improvements to provide drought period reliable capacity for the Upcountry District is limited but valuable.
    - These improvements would not appreciably increase the average supply of water to the Upcountry District system under average conditions.
- New growth in demand for water on the Upcountry District system is very expensive to provide, both in terms of capital costs and long term operating costs.
    - The amount of economical surface water available on the Upcountry systems is finite and is at its limits. Except for a limited amount of new capacity provided by additional raw water storage on the existing surface water systems, new growth will ultimately will be served by pumping up thousands of feet from basal groundwater aquifers.
    - Any new growth in water demand on the Upcountry systems be much more expensive to serve than existing demand and will cost much more than current system development fees provide.

Recommendations:

Based on these considerations the following plan components are recommended regarding acquisition of new potable water supply sources for the Upcountry District:

- DETERMINE THE OPTIMAL SPECIFIC LOCATION AND FEASIBLE CAPACITY AND PROCEED WITH DEVELOPMENT OF A NEW RAW WATER STORAGE RESERVOIR FOR THE LOWER KULA SURFACE WATER SYSTEM
    - Convene a meeting of principal environmental permitting agency representatives to discuss and determine probable constraints, conditions, mitigation measures and costs for alternative sites for a new reservoir
    - Proceed with studies to determine the feasibility, optimal reservoir capacity and location and, as determined to be appropriate, proceed with budgeting, environmental permitting and engineering for a new storage reservoir.
- DETERMINE WHETHER NEW BASAL WELLS OR A RAW WATER STORAGE RESERVOIR ARE THE PREFERRED METHOD TO PROVIDE DROUGHT PERIOD RELIABLE CAPACITY FOR THE UPCOUNTRY SYSTEM.
    - Determine whether incremental drought period reliable capacity additions that could be provided by developing or acquiring new basal wells should be deferred until a raw water reservoir can be commissioned for the Kamole WTP.
        - Determine the most likely magnitude of reduction in Wailoa Ditch base flows resulting from amendments of the IIFS on East Maui streams.
        - Refine capital cost estimates for a Kamole WTP reservoir project and determine capital funding alternatives.

    - Initiate discussions with Alexander and Baldwin regarding mutually productive protocols for allotment of water at Kamole Weir under varying ditch flow conditions.
    - Determine whether it is acceptable to defer the provision of new drought period reliable capacity that would be provided by incremental additions of basal wells until a Kamole reservoir can be put into service.
  - IF SO DETERMINED, ACQUIRE NEW BASAL WELLS DEVELOPED BY NON-DWS ENTITIES
    - Review all wells offered by non-DWS entities to assure that water quality, long term productivity, project engineering and materials all sufficiently meet DWS standards
    - Assure that all new water source contracts provide sufficient net benefits for existing DWS customers and prospective customers on the upcountry waiting list.
  - IF SO DETERMINED, PROCEED WITH DESIGN, PERMITTING AND CONSTRUCTION OF A RAW WATER STORAGE RESERVOIR TO SERVE THE KAMOLE WTP.
- INSTALL ADDITIONAL BOOSTER PUMP CAPACITY AS NECESSARY
  - Provide sufficient booster pumping redundancy to provide reliable service in extended periods of Phase 6 and Phase 10 pumping.
- INVESTIGATE FEASIBILITY AND PROCEED WITH IMPROVEMENTS TO KAMOLE WTP INTAKE STRUCTURES TO INCREASE DROUGHT PERIOD RELIABLE CAPACITY
  - Improvements could include a small raw water storage reservoir to increase operational flexibility of the Kamole WTP and reduce filtration costs by increasing water clarity.
- IMPLEMENT PROGRAMMATIC WATER CONSERVATION MEASURES
  - Immediately take steps to begin implementation of water conservation programs designed to attain at least 15% of the technical conservation potential for the Upcountry District within five years.
    - Budget for initial implementation of programs in FY2010.
    - Provide additional DWS staff positions and train existing DWS staff in indoor and outdoor conservation audit procedures, DSM contract management and program tracking and evaluation procedures.
    - Retain expert assistance to assist the DWS to determine optimal DSM program designs, solicit and procure DSM program implementation contracts, conduct necessary market research and publicity outreach, establish a portfolio of conservation programs for the DWS systems and implement accountable program tracking and evaluation procedures.
    - Establish and facilitate an agricultural water user group to discuss and promote water efficiency measures.
  - Based on experience with program implementation and based on continuing needs to defer the need for new supply resources consider more aggressive DSM programs.
- INVESTIGATE AND IMPLEMENT OPTIONS FOR IMPROVEMENTS THAT WOULD REDUCE SYSTEM OPERATION COSTS

- Determine the feasibility of installing a new storage tank and water supply line from the Kamole WTP to serve the Haliimaile service area without pumping to the elevation of the Pookela Tank.
- Determine the feasibility of installing a water line to drop water from the Lower Kula system to the Kula Agricultural Park to reduce pumping costs under some conditions.

- MAINTAIN OPANA / AWALAU AS A NON-POTABLE WATER SOURCE AND RESERVE FOR POSSIBLE FUTURE SOURCE FOR TREATMENT AND POTABLE USE

Regulatory Measures

- CONVENE DISCUSSIONS BETWEEN THE IMPLEMENTING AND AFFECTED AGENCIES AND STAKEHOLDERS TO RESOLVE MATTERS PERTAINING TO THE DISPOSITION, OPERATION, MANAGEMENT AND CONTROL OF THE UPPER KULA AGRICULTURAL NONPOTABLE WATER LINE.
- MAINTAIN AND/OR EXTEND INVERTED BLOCK AND PROGRESSIVE RATE DESIGNS: The existing DWS inverted block rate design is progressive in the respect that it provides aggressive price signals in the higher consumption blocks that encourage conservation and also provides lifeline rates for low volume consumers.
  - Consider increasing the rate block price differential and/or providing an additional higher cost block.
  - Ensure that all costs necessary to provide water services are included in rates.
- REVIEW SYSTEM EXPANSION FINANCING POLICIES AND/OR ESTABLISH SUFFICIENT SYSTEM DEVELOPMENT FEES
  - The County should establish sufficient and appropriate System Development Fees that are consistent with the fiscal purposes and policies of the DWS. The source and transmission components of the current fees are not sufficient to pay for commensurate new source and transmission improvements. As an alternative the County should consider revising its system development financing policies to provide debt financing for system expansion improvements where necessary.
  - Consider establishing specific system development fees for each district or system.
  - Consider waiving any future increases in system development fees for prospective customers who have been on the Upcountry waiting list for some specified period of time
- ESTABLISH WATER SOURCE DEVELOPMENT CONTRACT STANDARDS: The Maui County Code provides that approvals of new subdivisions require prior verification by the Water Director of a long term reliable source of water. In areas where the DWS does not currently have sufficient water capacity or production capability, potential land developers have a strong incentive to develop new potable water sources in order to obtain required verification. Few developers want to operate water sources or commit to providing perpetual water services. In most cases developers prefer to transfer ownership of a new water source to the DWS in trade for verification of water availability, entitlements to obtain water meters and/or source credits towards payment of DWS System Development Fees.

  From the perspective of potential source developers as well as for the interests of the County there is a need for clear policies and standards regarding water source contracts. Clear standards would provide fairness, encourage reasonable financial investments in new sources and ensure that new sources are safe, properly sited and contribute to the system planning and operation objectives of the DWS.

- SOURCE CREDITS: Establish clear and uniform standards for determining source credits
  - Source credits should be denominated in dollars towards the cost of system development fees at the time the source credits are redeemed (rather than in terms of capacity or meter equivalents).
  - Terms and transferability of source credits should be clearly established.
- ENTITLEMENTS: Establish clear and uniform standards for determining entitlements, reservations and verifications of water availability.
- WELL SITING: Establish standards and/or pre-established zones for well (or other source) location requiring consideration of:
  - Source / Wellhead protection to ensure long term water quality
  - Source elevation and impacts on water system operation costs
  - Proximity to existing water system transmission lines
  - Need to boost water to elevation of land developments
- SYSTEM INTEGRATION: Establish standards for integration of new sources with the DWS system
  - Need and role of new source in DWS long range system plans
  - Functional / operational role of the new water source
  - Variable and fixed operation costs
  - Storage and disinfection contact requirements
  - Design of new sources to DWS construction / engineering standards

- ESTABLISH CLEAR, MEANINGFUL CRITERIA FOR DETERMINING AVAILABILITY OF WATER AND NEED FOR NEW SYSTEM SUPPLY RESOURCES: The DWS needs to have a clear method to determine whether there are sufficient water resources and sufficient infrastructure to supply new water demands. This is necessary for several reasons including (1) the need to determine verifications of sufficient water source for new subdivisions, (2) the timing of need for new source development and capital improvements in order to maintain reliable water service and (3) implementing water allocation policies.
  - Commission a study/project to develop reasonable and useful system reliability standards, system capacity expansion criteria and methods to determine and express the status of water availability for new water services.

Resource Protection and Restoration

Actions, programs and measures to protect and restore cultural, watershed and groundwater resources are essential components of Maui's WUDP.

Watershed protection and restoration

Healthy forests and soil in our watershed areas are essential to maintain the healthy streams and ground water aquifers that are the source of our water supplies. These resources need protection and, in some places, substantial restoration. Healthy forests invite and capture precipitation, retain water to replenish aquifers, maintain base flow in streams, prevent soil erosion and flooding and maintain stream water quality.

- SUPPORT WATERSHED PARTNERSHIP AGREEMENTS
- SUPPORT FENCING AND UNGULATE CONTROL PROGRAMS TO PROMOTE REFORESTATION
- SUPPORT PROGRAMS TO CONTROL INVASIVE SPECIES

Wellhead protection

- IMPLEMENT A WELLHEAD / AQUIFER PROTECTION ORDINANCE FOR EACH ISLAND

Stream restoration

Healthy streams are essential to support Hawai'i's unique stream fauna and provide sufficient cool water necessary for growing taro.

- SUPPORT APPROPRIATE AMENDMENT OF INTERIM AND OR PERMANENT INSTREAM FLOW STANDARDS BY CWRM
- SUPPORT PROGRAMS TO PROTECT AND RESTORE STREAMS
- CONSIDER IMPACTS ON RELIANCE ON WATER FROM STREAMS IN COUNTY LAND USE DETERMINATIONS

Protection of Cultural Resources

- SUPPORT STREAM RESTORATION MEASURES
- CONSULT WITH BURIAL COUNCIL AND LOCAL KULEANA REPRESENTATIVES REGARDING DWS ACTIONS

Energy Efficiency and Energy Production

Energy costs are the single largest expense of the DWS. The DWS is the largest aggregate customer of Maui Electric Company (MECO). Opportunities to use energy more efficiently, manage the timing of electrical loads with MECO and to generate electrical energy can all benefit the County and DWS customers.

Efficient use of energy by the DWS will reduce costs to the County and DWS customers and reduce the impacts associated with electrical power production. Cost effective energy efficiency measures are consistent with all of the WUDP planning objectives.

Managing the timing of electrical energy use (load management) can be a valuable resource to MECO. The DWS can benefit by existing MECO load management incentives and by negotiating benefits resulting from future power management protocols with MECO.

The DWS has several opportunities to produce renewable energy for its own use that would reduce system costs. Renewable energy production opportunities are site specific due to the nature and availability of renewable energy sources and proximity to the DWS system electrical loads. Several specific opportunities for potential wind and hydroelectric generation have been identified for the Upcountry District. Opportunities for the Upcountry District will depend on the location of future resource development.

- ESTABLISH DWS ENERGY RESOURCE COORDINATOR POSITION
  - Establish a full time staff position or contract for assistance to monitor, investigate and implement energy efficiency programs, load management measures and energy generation opportunities
- IDENTIFY AND IMPLEMENT ENERGY EFFICIENCY OPPORTUNITIES
  - Participate in existing MECO energy efficiency programs

        - Prescriptive programs - Lighting in DWS buildings
        - Customized Rebate Programs - HVAC in DWS buildings and motor and pump efficiency investments
    - Participate in upcoming Public Benefit Fund Administrator energy efficiency programs
    - Invest in high efficiency equipment wherever cost effective
    - Monitor and optimize energy consumption of motor loads
        - Establish and monitor baseline efficiency metrics for pumping loads
        - Measure and monitor actual operational motor loads for energy diagnostics and optimization of equipment replacement
    - Establish system operation protocols that consider energy efficiency
        - Tabulate marginal operation costs for all system resources
        - Determine operational protocols to minimize energy costs without compromising system functionality
    - Optimize power factor correction on all large motor loads
        - Monitor balance of electrical service three phase legs
        - Determine and install optimum power factor correction capacitance for each large motor load
- IDENTIFY AND IMPLEMENT LOAD MANAGEMENT OPPORTUNITIES
    - Review and, as appropriate, amend MECO rate rider contracts
        - Balance MECO rate incentives versus system operation functionality
    - Monitor and negotiate load management opportunities, especially electrical system transient management services
        - Monitor MECO system needs and proposed measures to incorporate increased wind generation on the Maui electrical grid
        - Develop DWS load management protocols that are valuable to the MECO system.
        - Negotiate for shared system and economic benefits for load management services provided by DWS to MECO
- IDENTIFY AND IMPLEMENT ENERGY GENERATION OPPORTUNITIES
    - Monitor ongoing opportunities for cost effective energy generation to serve DWS electrical loads

Water Allocation Policies

This section of this report is currently drafted to provide an expository discussion of possible water allocation policies. As this matter is discussed in various public forums more concrete recommendations may be offered.

The State Water Code (Code) clearly provides that each county shall adopt a WUDP by ordinance **"... setting forth the allocation of water to land use in that county..."**[21] Apart from this unequivocal directive, however, the Code is silent and provides no further guidance regarding water allocations in the county WUDP's. The Code does not identify how the allocations should be made or what purposes they are intended to serve. The Code does not identify any context or venue in which the allocations should be applied nor does it explicitly provide any authority to implement or enforce water allocations.[22]

There have been discussions in several venues regarding allocations of water in the WUDP but there is no consensus regarding how the allocations should be expressed or how they should be applied. There are diverse opinions on this matter.

In order to provide a starting point for further detailed discussion regarding the "allocation of water to land use" in the WUDP, several clarifications and approaches are outlined below.

Venues and Purposes for Allocations

Water allocation in the WUDP can serve several purposes, either as guidelines or as rules.

- Water allocation policies established in the WUDP can serve as ***guidelines:***
    - To the CWRM regarding amendments to interim instream flow standards (IIFS) and establishing instream flow standards (IFS)
        - These CWRM standards determine allocation of water to in-stream versus off-steam uses
    - To the CWRM regarding allocation of water to competing uses and users in water management areas.[23]
        - Permits for water use issued by the CWRM in surface water management areas explicitly allocate water between instream uses and offstream uses as well as between competing off-stream users.
        - Permits for water use issued by the CWRM in ground water management areas explicitly allocate water, within aquifer sustainable yields, to competing ground water uses and users.
    - To the DWS in making decisions within its discretionary authority
    - To state and county agencies, including the Maui County Council, in determining rules, ordinances, policies and plans, including the General, Island and Community Plans.
- Water allocation policies in the WUDP can potentially serve as **rules** regarding determinations within the authority of the Maui County Council:
    - Rules regarding actions by the DWS including
        - Issuance of water meters
        - Issuance of reservations for water meters
        - Certification by DWS Director of availability of reliable source of water supply necessary for subdivision approvals
        - Approval of contracts with water source developers

21. HRS 174C-31(a)(2)

22. The County certainly may have authority to allocate water provided by the DWS to DWS customers but this authority does not derive from the Code's language regarding the Hawaii Water Plan or the County Water Use and Development Plans. There is a distinction between "users" in the context of the Code and DWS customers. In the context of the Code the DWS is a "user" but the DWS customers are not users. The DWS serves many customers

23. In the context of allocation of water by the CWRM, the DWS is a "user" but individual DWS customers are not "users" by way of receiving water from the DWS. These allocations are made in accordance with the provisions of the State Water Code, HRS Chapter 174C. Allocations of water between existing and potential DWS customers are determined by the County in accordance with DWS policies and county ordinances and rules.

        - Development of DWS supply and transmission resources
        - Restrictions on certain water uses during drought or temporary system deviance
    - Rules regarding actions by County agencies including
        - Planning Commission
        - Department of Public Works
        - Planning Department permitting and/or subdivision approvals
        - Board of Variance and Appeals actions
    - Rules with respect to the actions listed above regarding set asides or reservations for specific priority uses, possibly including
        - Affordable housing projects
        - Kuleana or public trust domestic uses
        - Hospitals or other municipal emergency or public service uses
        - Department of Hawaiian Homelands (DHHL) projects
        - General or specific agricultural uses

Hierarchy of Priorities

A general hierarchy could be outlined to establish water use priorities. Outlined below is one example of a hierarchy of priorities of water use derived from existing law and practical considerations:

- Public Emergency Uses (Temporary)
    - Fire control
- Public Trust Uses
    - Instream uses
    - Kuleana kalo, subsistence agriculture and domestic uses
- Reasonable / Beneficial Uses
    - Essential municipal public service uses (hospitals)
    - DHHL domestic uses
    - Domestic uses
    - DHHL agricultural uses
    - Agricultural uses
    - Government uses (offices)
    - Hotel / Commercial / Industrial uses
    - Non - essential municipal public service uses (parks)
    - Landscape Irrigation uses
- Non-Reasonable / Non-Beneficial Uses
        - Excessive or Purposeless Commercial uses
        - Wasteful or Excessive Landscape irrigation uses
        - Waste

Set-Asides

Amounts of water could be set aside for specific users or uses. For example, it could be determined that a specific amount of water or a percentage of available water would be set aside for DHHL projects, for affordable housing, for agriculture, or other projects determined by the Council. Implementation of a set-aside policy requires quantification of the total amount of water available and the amounts already committed to existing and "entitled" uses. This approach requires several determinations and presents several challenges. It would be necessary to:

- Determine what categories of water users or uses would have water set aside
- Determine what amounts of water would be set aside for each beneficiary category of users or uses
- Determine whether the set-asides would be applied to the County as a whole, to each island or to specific areas, districts or systems.
- Establish a clear and concise method of determining, on an ongoing basis, how much total water is available to be allocated. It would have to be determined whether the set-asides would allocate portions of
  - potential sources (aquifer sustainable yields or stream flows),
  - existing developed infrastructure (existing wells, treatment plants, transmission and storage), or
  - planned infrastructure.
- If set-asides are made against planned infrastructure it would have to be determined what threshold would determine whether water would be considered "available"
  - source construction contract ?
  - feasibility study ?
  - inclusion in the CIP ?
  - inclusion in the WUDP?
- Establish a clear and concise method of determining, on an ongoing basis, how much of the total available water is already committed. This could include any of several categories of use:
  - use by existing customers with meters
  - average historical consumption basis ?
  - expected continued increase in use per meter (as lots with meters are improved and "built out".
  - anticipated use by projects and subdivisions that have some level of implicit or explicit entitlement or reservation
  - verification of long term water source by the DWS director
  - water meter reservation
  - land use approvals
  - water promised or committed by source development contracts
  - water promised or committed by contract with DWS (letters or memoranda of understanding)
- Determine at what stage of which process the set aside allocations would be determined and at what stage the determinations of net availability would be

applied:

- in General, Island or Community Plan land use designation process ?
- in the WUDP ?
- as a set aside allocation ordinance ?
- at time of subdivision verification of water source availability by DWS director?
- at time of reservation or issuance of water meter ?

Allocations of Specific Water Sources to Land Use

Specific water sources could be allocated to specific land uses or categories of land uses.[24] For example, the output of a specific well or production tunnel could be allocated to municipal potable use. Raw water from a specific diversion or reservoir could be allocated to agricultural uses in a specific area. Specific allocations of water for instream uses could be identified.

Statements of Allocation Policies

The County could express its allocation of water to land use by stating policies that should apply generally or to specific circumstances. Some examples are provided, including statements of policy that have been suggested in the WUDP public process:

- Maintain mauka to makai flow in Maui's streams
- Return all water to the streams
- Give priority to riparian, kuleana and instream uses
- Give priority to DHHL uses
- Use ground water for potable uses and surface water for non-potable uses
- Provide for the needs of existing users before allowing new uses (land development)
- Give priority to residents' needs over visitor industry needs

24. It is recognized that the County may not have explicit authority to directly allocate water from some specific sources. In these cases the allocations would serve as policy statements.

Appendix A - Analysis of Demand Side Management (Conservation) Program Portfolios - Upcountry District

Demand Side Management (Conservation) Programs

“Demand side management” (DSM) is a utility industry term of art that describes actions that can be taken by a utility to affect how the utility’s commodity is used by its customers. Originally applied to the electric utilities and applied now also to gas and water utilities, DSM options have proven to be valuable “resources” to meet utility planning objectives.

DSM resource options are usually programs undertaken by a utility to encourage the use of efficient appliances or practices by its customers or to encourage customers shift their time of use. DSM programs often use incentives such as monetary rebates to encourage purchase of efficient appliances. More intensive DSM programs include direct installation of new efficient fixtures by the utility (or a contractor paid by the utility) at customers’ premises.

DSM programs are evaluated based on a comparison of the costs of implementing the programs with the costs the utility and its customers would otherwise incur to develop and operate new supply resources.

DSM programs are included in all of the final candidate strategies.

The analysis of DSM programs for the Upcountry District strategies was conducted in several steps:

- Characterization and Evaluation of Individual DSM Measures
- Preliminary Analysis of Candidate DSM Programs
- Characterization of Water End Uses by District
- Estimate of DSM Technical Potential
- Estimate and Analysis of DSM Econimoc Potential
- Analysis of Magnitude and Pacing of DSM Programs
- Independent Expert Review of DSM Analysis and Program Design
- Specific DSM Program Design and Contracting

Each of these steps is described below:

Characterization and Evaluation of Individual DSM Measures

Analysis of an inclusive list of possible DSM measures is presented in the Resource Options Chapter. In this analysis, each DSM measure was characterized in terms of the fixture costs, installation costs, program administration costs and average expected water savings. The costs and benefits of each measure were characterized in terms of the levelized life cycle costs per thousand gallons of water saved. This analysis does not explicitly consider the operational benefits of the DSM measures in the specific context of the water system or possible future resource strategies.

Preliminary Analysis of Candidate DSM Programs

Analysis of several candidate DSM programs was presented in the Candidate Strategies Chapter. The purpose of these analyses was to determine, generally, whether DSM programs could be an effective and cost effective means to meet Upcountry District water needs. In these analyses several example porfolios of DSM programs were examined in the specific context of the

Upcountry District system using the integrated capacity expansion and production cost analysis model for each of several candidate resource strategies.

The candidate DSM portfolios in these preliminary analyses included a toilet retrofit rebate program, a commercial urinal retrofit program, an irrigation efficiency program and a xeriscaping program. For purposes of these preliminary analyses assumptions regarding program impacts and costs were the same as used in the Central District analyses. Labor assumed in characterizing the portfolio of programs includes four full time staff. The annual budget for the portfolio of programs includes $261,000 of rebates, $240,000 incremental administration costs and presumes $150,000 of costs born by program participants. The total annual utility costs are the sum of the rebates and administrative costs ($501,000). The total resource costs are the sum of the utility costs and the costs to participating customers ($651,000). The portfolio impacts are estimated to reduce metered consumption by 88,000 gallons per day for each year of program implementation. For purposes of analysis these impacts are distributed to each of the Upcountry District subsystems according to the proportion of residential consumption. The life of the measures is assumed to be fifteen years.

For purposes of sensitivity analysis several other portfolios were examined including a portfolio with twice the assumed penetration and a portfolio with higher administrative costs.

The preliminary analyses described above are documented in the Upcountry Candidate Strategies Chapter. As reported in that Chapter, the DSM programs examined in this analysis proved to be effective and cost effective in the context of the candidate strategies. Based on these results more detailed characterization and analyses were conducted.

Characterization of Water End-Uses by District

The analyses described above characterize the economic benefits of several DSM programs but do not determine the amount of water savings that would ultimately be possible. The magnitude of potential water savings was determined in three progressive steps: end-use analysis, estimation of technical potential and estimation of economic potential.

End-use analysis determines how much water is used for different ultimate purposes. For the Upcountry District the amount of water use was determined for each class of customers. For domestic uses the amount of water use was estimated for each of several end use categories. A summary of the results of this analysis is portrayed in the tables below.

DWS CY2006 Consumption (MGD)			
	Makawao Pukalani Kula CPD	Paia Haiku CPD	Upcountry District
Agriculture	2.70	0.16	2.86
Commercial	0.17	0.06	0.23
Industrial	0.00	0.02	0.02
Domestic Indoor	1.68	0.82	2.50
Outdoor (Non-Ag)	1.68	0.41	2.09
Total	6.22	1.47	7.70

CY2006 Domestic Indoor Consumption (MGD)			
	Makawao Pukalani Kula CPD	Paia Haiku CPD	Upcountry District
Toilets	0.41	0.19	0.60
Showers	0.32	0.15	0.47
Baths	0.14	0.07	0.21
Faucets	0.43	0.21	0.64
Dishwashers	0.02	0.01	0.03
Clothes Washers	0.36	0.19	0.55
Total	1.68	0.82	2.50

Estimate of DSM Technical Potential

The DSM technical potential is the amount of water that could be saved using efficient fixtures and practices. For the purposes of this analysis the technical potential is defined as the amount of water that would be saved if all fixtures in the district were converted to fixtures meeting the current effective code efficiency standards.[25] The results of the quantification or the technical potential for various domestic end uses for the Upcountry District is presented in the table below.

DSM Technical Potential (MGD)			
	Makawao Pukalani Kula CPD	Paia Haiku CPD	Upcountry District
Toilets	0.23	0.10	0.32
Showers	0.12	0.05	0.16
Baths	0.00	0.00	0.00
Faucets	0.12	0.05	0.17
Dishwashers	0.01	0.00	0.01
Clothes Washers	0.13	0.07	0.20
Total Indoor	0.60	0.26	0.87
Outdoor Irrigation	0.59	0.14	0.73
Total	1.19	0.41	1.60

The estimate of technical potential includes an assessment of the vintage of existing water fixtures determined from Maui County Tax Division records. The consumption of existing fixtures was estimated from fixture vintage based on the date of the last building permit for each TMK.

If all fixtures in the Upcountry District were upgraded to the efficiency standards in current codes indoor water use would be reduced by approximately 0.87 MGD. This equals about 35% of indoor domestic consumption and equals about 11% of total Upcountry District DWS system 2006 metered consumption.

25. Technical potential is sometimes defined as the amount of savings that would result from implementation of the most efficient fixtures and technologies available. The definition of technical potential used in the analyses reported here is, in this respect, somewhat conservative. For example, installation of dual-flush toilets that consume about 1.0 gallons per flush (gpf) are available and are being considered. The technical potential estimates above assume that 100% of all fixtures would be 1.6 gpf fixtures in compliance with existing codes.

Domestic outdoor use is primarily irrigation of plants. The technical potential estimate is based on an estimate of 35% reduction of outdoor irrigation use that would result from eliminating all over-watering of plants and eliminating waste due to poorly designed and/or maintained irrigation systems. This estimate is based on industry literature and discussion with local irrigation system industry personnel. 35% of 2006 estimated domestic outdoor irrigation use equals 0.73 MGD. This does not include any potential for reducing estimated agricultural sector water use.

The total technical potential of indoor and outdoor measures (excluding agricultural uses) is estimated to be 1.6 MGD which equals about 21% of Upcountry District 2006 total metered consumption and about 33% of total non-agricultural potable metered consumption. For practical purposes it is important to note that the estimates of technical potential assume upgrading ALL fixtures to current code standards and improving ALL irrigation to optimum practices. Assessments of realizable "economic" potential are determined by further analysis as described below.

Estimate and Analysis of DSM Economic Potential

Estimates and characterization of the practical, economic potential of implementing DSM programs was made in several stages. Initially, the economics of several DSM programs was examined in the analysis of the candidate strategies as described above. Based on the end-use analyses and the estimates of technical potential the economics of a portfolio of more refined and specific DSM programs was examined to explore the optimum magnitude and pacing of program implementation. This is described in the section below. After these analyses were conducted, a nationally recognized water conservation program expert was retained to visit Maui, review the assumptions, programs and analysis methods used and to recommend a specific portfolio of DSM programs for Maui's water systems.

Analysis of Magnitude and Pacing of DSM Programs

DSM programs can be implemented with differing degrees of intensity. Modest rebate programs can be expected to result in modest amounts program participation and modest reductions in water use. With additional expenditures on DSM programs, providing higher incentives or direct installation of fixtures, higher amounts of program participation and water savings can be expected... but at a higher cost per unit of savings. Depending upon the circumstances and needs of the water system, higher expenditures on DMS programs may be more effective and more cost effective... but only to a point of diminishing returns.

In order to determine the optimum magnitude and pacing of DSM programs several analyses were conducted using the integrated capacity expansion and production cost model for the Upcountry District. A portfolio of DSM programs was characterized and applied in differing degrees of magnitude and pacing to compare the resulting effectiveness and cost effectiveness in the context of each of several final candidate strategies. The results of several analyses are provided below.

The portfolio of programs used in the Upcountry District analysis includes only indoor measures. The indoor measures include direct installation of efficient toilets, showerheads and sink fixture flow restrictors for domestic units. Outdoor measures would provide further possible economic water conservation potential but are not currently sufficiently characterized for the Upcountry Distric are for quantitative analysis.[26]

The differing intensities of program magnitude and pacing were analyzed based on an initial base program portfolio designed to attain 15% of the DSM technical potential in a period of five

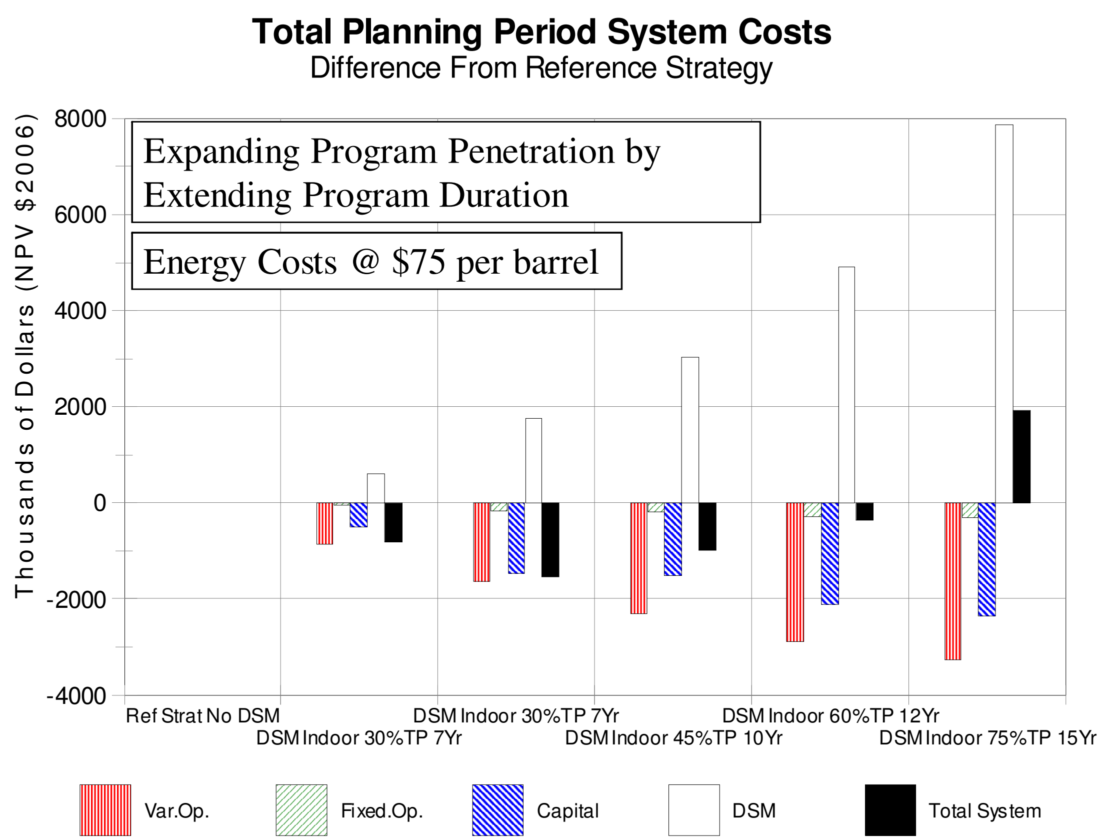
26. The landscape irrigation efficiency program measures characterized and analyzed for the Central District systems would not be broadly applicable to the typical domestic outdoor water uses in the Upcountry District. Programs appropriate for the Upcountry District will be designed in conjunction with specific proposals from DSM service providers.

years. Differing intensities of DSM program implementation were analyzed as multiples of the base program with corresponding associated costs and impacts.

The base indoor program portfolio, including direct retrofit of domestic toilets, showerheads and sink faucet restrictors results in a reduction of water use of 26,000 gallons per day for each year of program implementation at a total cost (customer and utility cost) of $162,000 per year. This base program would result in attaining 15% of the DSM technical potential after five years of implementation. This means that the program would result in 15% of the possible saving that would result if ALL indoor domestic fixtures were upgraded to current code standards.

The basic program, for example, would reduce water consumption by 26,000 gallons per day for each year of program implementation. This would result in a reduction of water consumption of 130,000 gallons per day after five years of program implementation. This is equal to 15% of the 0.87 MGD indoor DSM technical potential for the Upcountry District.

Alternate magnitudes and pacing of DSM program implementation were analyzed assuming program intensities that would attain 30%, 45%, 60% and 75% of technical potential. Increasing the intensity of program implementation would require higher costs per unit of savings due to the need to use higher incentives, more expenditure on publicity and advertising and increasingly expensive measures in the portfolio of DSM programs. For example, to attain higher percentages of the technical potential it would be necessary to include substantial installation of more expensive measures such as high efficiency clothes washers and dishwashers.



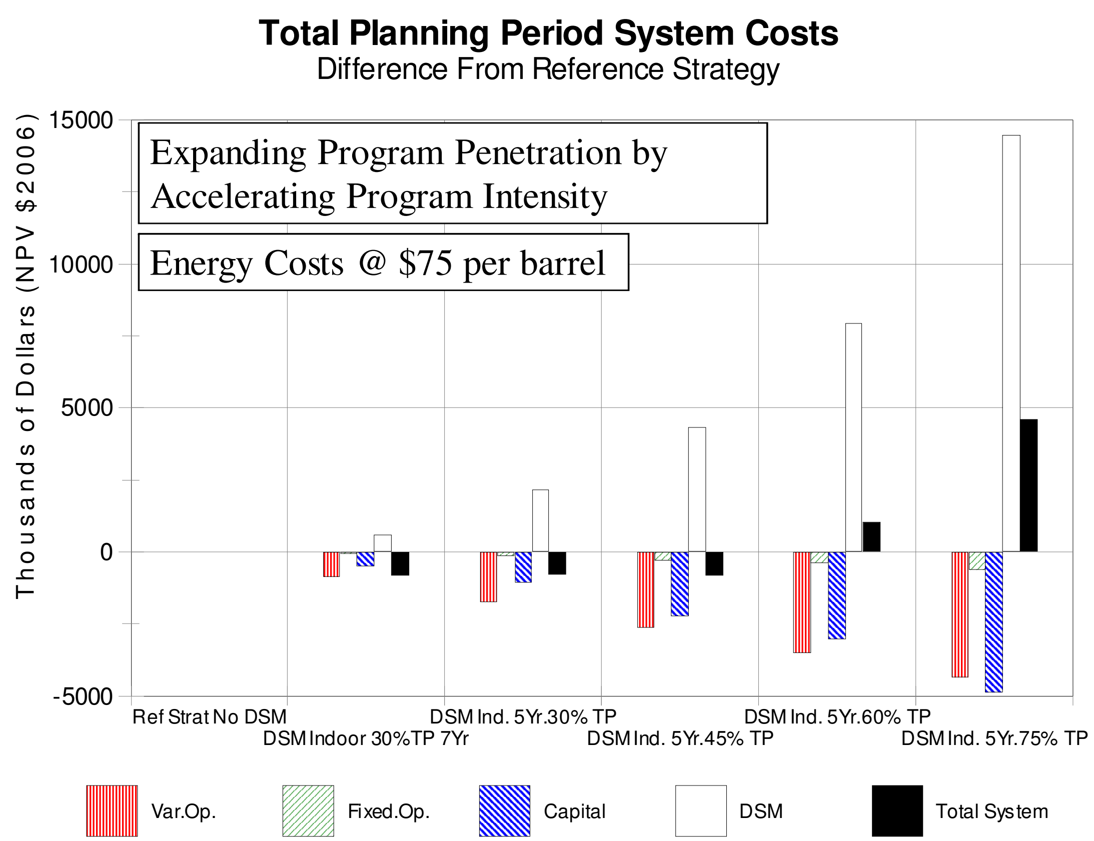
Upcountry District Reference Strategy with Alternate Levels of Indoor DSM Program Penetration with Progressively Extended Program Duration

Analysis of alternate levels of indoor DSM program penetration with progressively extended program duration.

The chart above shows the DSM costs and resulting planning period cost impacts of implementing an indoor DSM program with increasing duration and an increasing portfolio of measures. The base program attains 15% of the DSM technical potential in five years. Alternate levels of implementation attain 30%, 45%, 60% and 75% of the DSM technical potential in seven, ten, twelve and fifteen years respectively. The longer duration programs include progressively higher levels of incentives, more expensive delivery mechanisms and more expensive measures in later years to achieve higher levels of program participation.

This analysis demonstrates that increasing the duration and intensity of program implementation yields diminishing returns. This is expected since it is necessary to employ more expensive program delivery mechanisms and to target more expensive water saving measures in order to achieve higher proportions of DSM technical potential. In this analysis a twelve year program to attain 60% DSM technical potential is cost effective but a fifteen year program to attain 75% DSM technical potential is not.

Several other analyses were performed using alternate assumptions and using different candidate strategies as the reference plan.



Upcountry District Reference Strategy with Alternate Levels of Indoor DSM Program Penetration Using Accelerated Program Pacing to Attain Water Savings Within Five Years

Analysis of alternate levels of indoor DSM program penetration using accelerated program pacing to attain water savings within five years.

The chart above shows the DSM costs and resulting planning period cost impacts of implementing an indoor DSM program with increasing “pacing” and an increasing portfolio of measures. The base program attains 15% of the DSM technical potential in five years and is identical to the base program in the analysis presented on the previous page. Alternate levels of program implementation attain 30%, 45%, 60% and 75% of the DSM technical potential in five years using progressively higher levels of incentives and more expensive measures to achieve a higher rate of program implementation.

As shown with the analysis presented on the previous chart, increasing the intensity of program implementation yields diminishing returns. Increasing the pace of program implementation as shown here is a more expensive way to achieve higher portions of DSM technical potential than by increasing program duration. This is because more expensive program delivery mechanisms are necessary in order to increase the pace of the programs. It is also less feasible to optimize program cost effectiveness by capturing as much of the less expensive program opportunities in the early years of program implementation. In this analysis it is not cost effective to achieve more than 45% of the DSM technical potential in a five year period. Depending upon the specific characteristics and immediate needs of the water system it may be more cost effective to accelerate the pacing of DSM programs in some circumstances.

Several analyses were performed to test the cost effectiveness of several DSM program portfolios under alternate assumptions. The DSM programs were also tested in conjuction with all of the final candidate strategies. In all cases the basic DSM program portfolio of indoor and outdoor programs designed to attain 15% of technical potential was cost-effective.

The analyses shown above reflect electrical energy costs associated with world oil prices at approximately $75 per barrel consistent with the “low” energy price scenarios presented in the final candidate strategies report. During the year 2008 in which the final candidate strategies were examined, energy prices increased dramatically to over $140 per barrel and, by the end of the year fell again to under $40 per barrel. Several analyses of the DSM programs were performed assuming a range of energy prices. In the “high” energy price scenarios (equivelent to $125 per barrel crude oil price), the DSM programs, as expected, were determined to be more cost effective than in the lower price scenarios.

Independent Expert Review of DSM Analysis and Program Design

In order to verify the reasonableness of the characterization and analysis of DSM programs a nationally renowned expert was retained. Amy Vickers, the author of an authoritative text on water conservation, Water Use and Conservation, was retained to visit Maui and provide a critical review of the DSM program analyses and provide a recommended portfolio of DSM programs appropriate for Maui’s systems. The review included a spectrum of site visits to agricultural, commercial and domestic properties across the island, a technical review of the methods used in the analyses described above, meetings with DWS staff and a Powerpoint presentation of findings to the County Council Water Resources Committee.

Ms. Vickers approved of the analytical methods used but recommended some different DSM program designs and delivery mechanisms than were assumed in the analyses. After careful review it was determined that the programs used in the analyses are sufficient to conservatively demonstrate the value and cost effectiveness of a portfolio of DSM programs[27] but that a different portfolio of programs should be considered for implementation for Maui’s systems. In particular, Ms. Vickers recommended against basing the outdoor DSM programs primarily upon the

27. The DSM program portfolio recommended by Ms. Vickers was determined to cost less and result in at least as much reduction in water usage as the program portfolio included in the analyses described above. The findings of the prior analyses, that the portfolio of DSM programs would be cost-effective, is therefore likely to be “conservative.”

installation of ET irrigation system controls . Ms. Vickers recommended the following portfolio of DSM programs:

- Residential / Commercial Audit and Direct Installation Program for Indoor and Landscape Irrigation Users
- Education and publicity program to encourage water conservation and promote program participation
- Direct installation of efficient fixtures at customer premises including toilet, showerhead and sink faucet flow restrictors
- Audit of existing irrigation system equipment and practices and specific resulting recommendations to customer to improve efficiency
- Direct Installation of Targeted “High Payback” Fixtures in Commercial Premises
- High Efficiency Fixture Rebates
- High efficiency washing machines
- High efficiency toilets and waterless urinals
- Hotel Awards Program
- Building Manager User Group and Services
- Agricultural User Group and Services

Specific DSM Program Design and Contracting

The analyses described above conclude that a portfolio of DSM programs would be beneficial and cost-effective for the Upcountry District system. As recommended in the Upcountry District Final Candidate Strategies Report, the next step towards implementing a DSM program for the DWS would be to obtain proposals and bids from companies that implement water utility DSM programs. This will provide more specific cost and impact estimates that can be used in further economic analysis.